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PROCEEDINGS, 27TH ONTARIO WASTE CONFERENCE, 1980.

PROCEEDINGS

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27th Ontario Industrial Waste Conference

June 15 – 18, 1980
The Prince Hotel
Toronto, Ontario

Earth Sciences Library



Ministry
of the
Environment

Hon. Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott, Q.C.,
Deputy Minister



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**Proceedings
of the
Twenty-seventh
Ontario Industrial Waste Conference**

held at

**The Prince Hotel
Toronto, Ontario**

June 15-18, 1980

**Sponsored by the
Ontario Ministry of the Environment**

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Province of Ontario

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Mayor

City of Mississauga

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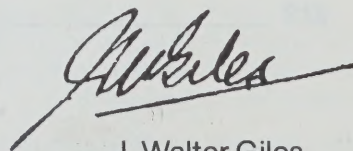
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PREFACE TO THE PROCEEDINGS OF THE 27th ONTARIO INDUSTRIAL WASTE CONFERENCE

On behalf of the Conference Planning Committee and the Technical Program Committee, I extend our appreciation to all those who contributed to the outstanding success of the 27th Ontario Industrial Waste Conference. For the first time in the history of the Conference, registration passed the 600 mark — actually there were 609 participants. This total was comprised of 525 delegates and program personalities, 60 spouses, and 24 committee members, staff and media representatives. A most creditable response and a conclusive indication that the Industrial Waste Conference is meeting an environmental need that is continuing to attract representatives from industry, consulting firms, educational institutions, plus a broad mix from allied interests in industrial abatement, pollution control and waste management.

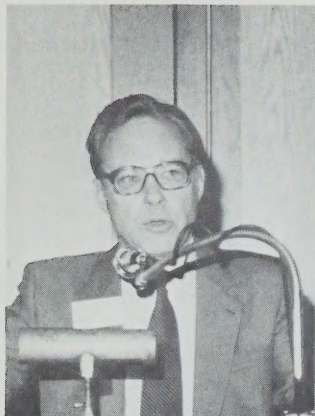
A particular thanks to the session chairmen, program participants and all those who were instrumental in melding the agenda in such a way that the delegates were rewarded with new ideas, abatement techniques and a great deal of 'food for thought'. The papers were well-prepared and presented, and through the adeptness of each of the session chairmen, the program flowed without a hitch. And, of course, as the Conference Chairman, I cannot neglect expressing a special thanks to the Technical Program Committee members, and the Planning Committee, for their special dedication in seeing that everything meshed to make the 27th so successful a conference.

On behalf of the Ontario Ministry of the Environment, thank you for participating. The following Proceedings will give you a permanent record of what transpired. The 1981 Industrial Waste Conference will again be held at the Prince Hotel in Toronto. The dates for our 28th Conference are June 14 - 17, 1981. Naturally, you and your associates are invited to attend.



J. Walter Giles,
Conference Chairman

CONFERENCE PLANNING COMMITTEE

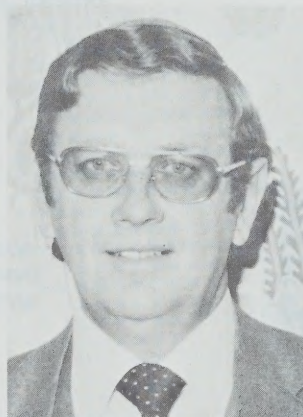


Conference Chairman

J. W. Giles, Assistant Deputy Minister, Environmental Assessment and Planning, Ontario Ministry of the Environment

Vice-Chairman

L. F. Pitura, Director, Waste Management Branch, Ontario Ministry of the Environment



Program Convener

R. C. Stewart, Manager Technical Support, West Central Region, Ontario Ministry of the Environment



Conference Co-Ordinator

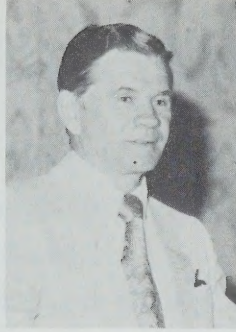
M. F. Cheetham, Co-Ordinator Education & Public Affairs, Information Services Branch, Ontario Ministry of the Environment



TECHNICAL PROGRAM COMMITTEE

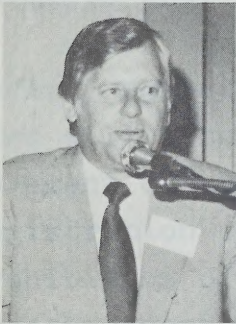
- N. Borodczak, Head, Water and Wastewater Approvals Unit, Environmental Approvals Branch, Environment Ontario
- B. Boyko, Supervisor, Technology and Marketing Unit, Waste Management Branch, Environment Ontario
- C. E. Duncan, Manager Industrial Abatement, West Central Region, Environment Ontario
- J. R. Hawley, Head, Mining and Metallurgy Unit, Waste Management Branch, Environment Ontario
- P. Kupa, Head, Criteria and Regulations, Air Resources Branch, Environment Ontario

SESSION I
CHAIRMAN



W. Bidell

Assistant Deputy Minister
Regional Operations & Laboratories
Ministry of the Environment, Toronto



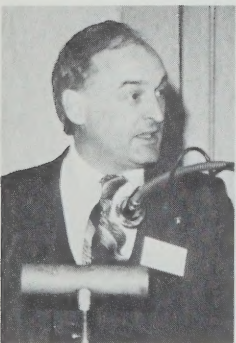
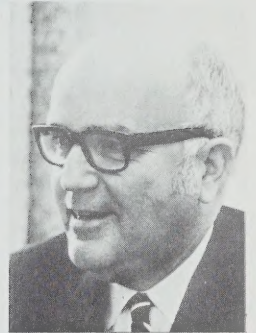
**Ontario's Progress in Managing
Hazardous Wastes**

E. W. Turner, Manager, Waste Systems
Planning Section, Waste Management
Branch, Environment Ontario, Toronto

**Some Possible Management Plans for the
Treatment/Disposal of Liquid Industrial
and Hazardous Wastes in Ontario**

J. W. MacLaren
Chief Executive Officer
James F. MacLaren Limited, Toronto

O. Martini
Project Manager
James F. MacLaren Limited, Toronto



**Hazardous Wastes Strategy for
Western Canada**

E. E. Kupchanko
Assistant Deputy Minister
Environmental Protection Services
Alberta Environment, Edmonton

ONTARIO'S PROGRESS IN MANAGING HAZARDOUS WASTES

by

E.W. Turner, Manager, Industrial Section,
Waste Management Branch, Environment
Ontario, Toronto

A report and **progress** on the implementation of the Minister's Seven-Point Program for the management of liquid industrial wastes and hazardous wastes. Highlights include:

- Interim storage of PCB's (Dillon Study);
- Research on PCB destruction;
- The St. Lawrence Cement Project (PCB incineration);
- Solidification proposals on interim treatment of wastes;
- The Ajax proposal for a waste treatment facility (Region of Durham);
- Research into waste treatment.

Proposed regulations and guidelines for improved management of wastes will also be reviewed, including:

- Movement of equipment containing PCBs;
- Registration of wastes by generators;
- Prohibition of landfilling;
- Transboundary movement of wastes; and
- Perpetual care.

Note: Mr. Turner spoke from notes and personal experience. He did not have a formal text prepared which could be included in these Proceedings.

Following are the texts from the overhead transparencies which the speaker used to illustrate his subject.

DEFINITION

"HAULED LIQUID INDUSTRIAL WASTES"

THOSE WASTES GENERATED BY MANUFACTURING OR PROCESSING OPERATIONS WHICH ARE HAULED AWAY FROM THE PLACE WHERE THEY ARE GENERATED TO ANOTHER LOCATION, EITHER OFF-SITE OR ON-SITE, FOR TREATMENT AND/OR DISPOSAL.

HAULED LIQUID INDUSTRIAL WASTES INCLUDE INDUSTRIAL WASTE SLUDGES, SEMI-SOLIDS AND SOLID WASTES.

ONTARIO'S SEVEN POINT PROGRAM FOR LIQUID INDUSTRIAL WASTE DISPOSAL

1. FACILITIES

- WORK WITH PRIVATE SECTOR
- LONG-TERM WASTE MANAGEMENT PLAN
- ACQUISITION OF SITES

2. INTERIM MEASURES

- GUIDELINES
 - TREATMENT AND DISPOSAL
 - LANDFILL PROHIBITION
 - MONITORING AND CONTROL
- WASTE STORAGE
 - PCB
 - OTHER WASTES

3. WAY-BILL MONITORING

- EDP SYSTEM

4. WASTE CLASSIFICATION

5. REGULATIONS

- LANDFILL PROHIBITION
- TREATMENT AND DISPOSAL
- REGISTRATION OF WASTES

6. PERPETUAL CARE

- STUDY
- REGULATIONS

7. TRANSBOUNDARY MOVEMENT OF WASTES

FACILITIES FOR LIQUID INDUSTRIAL WASTE TREATMENT AND DISPOSAL

A) GOVERNMENT

MacLAREN STUDY

- LONG-TERM WASTE MANAGEMENT PLAN
- FIVE YEARS TO DEVELOP AND IMPLEMENT(?)

B) PRIVATE SECTOR

REGION OF DURHAM PROPOSAL TO CONVERT THE AJAX STP INTO PHYSICAL/CHEMICAL TREATMENT FACILITY

- ENVIRONMENTAL HEARING UNDER THE
ENVIRONMENTAL PROTECTION ACT COMMENCED
DECEMBER 17, 1979. DUE TO BE COMPLETED
JUNE 20, 1980.

C) PCBs

1. MacLAREN STUDY TO INCORPORATE NEED FOR
PCB DESTRUCTION FACILITIES
2. ST. LAWRENCE CEMENT KILN
 - TEST BURN
 - CITY OF MISSISSAUGA BY-LAW

INTERIM MEASURES

1. LIQUID INDUSTRIAL WASTES

A) IMPROVED MONITORING AND CONTROLS ON 22
LANDFILL SITES CURRENTLY ACCEPTING LIQUIDS

B) LIMITED-TERM (FIVE YEARS) SOLIDIFICATION
PROPOSALS

- BROWNING-FERRIS INDUSTRIES LIMITED
AT RIDGE LANDFILL SITE IN TOWNSHIP
OF HARWICH

- WALKER BROTHERS QUARRIES LIMITED AT
QUARRY SITE IN ST. CATHARINES AREA

- PROPOSALS SUBJECT TO THE ENVIRONMENTAL
ASSESSMENT ACT

- MINISTRY OF THE ENVIRONMENT CO-PROONENT

- DOCUMENTS FILED WITH MINISTER ON MAY 9, 1980.

- HEARING IN LATE FALL?

INTERIM MEASURES

2. PCBs

A) M. M. DILLON STUDY ON INTERIM STORAGE OF PCBs

- REVIEW OF CROWN LANDS (AND OTHERS) IN PROVINCE
- THREE PREFERRED SITES
 - ONTARIO HYDRO TRANSFORMER STATION IN MIDDLEPORT
 - CAYUGA PROPERTIES
 - RIDGE LANDFILL (BFI)
- MINISTRY ELECTED TO PROCEED WITH MIDDLEPORT:
 - GOVERNMENT OWNED LAND;
 - CLOSE TO CENTROID OF WASTE PCB GENERATION;
 - REASONABLE ROAD ACCESS;
 - NOT CLOSE TO URBAN AREA
- SUBJECT TO ENVIRONMENTAL ASSESSMENT ACT
- CONSULTANT PRESENTLY PREPARING ASSESSMENT DOCUMENTS (6 MONTHS)

B) REGULATION ON MOVEMENT OF PCBs

(TO BE DEALT WITH LATER)

RESEARCH - LIQUID INDUSTRIAL AND HAZARDOUS WASTES

- MINISTRY WILLING TO FUND RESEARCH INTO PROMISING TECHNOLOGIES.

1. PCBs

A) RESOURCE RECOVERY CORPORATION:

PLASMA ARC PROCESS; RMC, KINGSTON;
ONE YEAR; \$400,000

B) SJT CONSULTANTS LIMITED - "CANPOB DESTROYERS":

ROCKET ENGINE; HIGH TEMPERATURE PLASMA
USING H_2 AND O_2 ; ONE YEAR; \$400,000

C) UNIVERSITY OF WATERLOO:

CHEMICAL DESTRUCTION OF PCBs USING SODIUM
NAPHTHALENIDE; COMPLETE FALL, 1980,
\$18,000

ALSO FOLLOWING UP ON:

A) LOCKHEED, CALIFORNIA, U.S.A. MICROWAVE PLASMA PROCESS

B) CHEMICAL WASTE MANAGEMENT (D & D) DIESEL ENGINE PROCESS

- TEST RUN AT ORF, MISSISSAUGA, AT
END OF JUNE

- FULL-SCALE PROTOTYPE UNIT TO BE
BUILT AND OPERATED IN MARYLAND, U.S.A.
WITH FUNDS FROM U.S. EPA AND THE
STATE OF MARYLAND

RESEARCH - LIQUID INDUSTRIAL AND HAZARDOUS WASTES (CONT'D)

1. PCBs (CONT'D)

c) HYDROTHERMAL DECOMPOSITION OF PCBs, KOCHI UNIVERSITY, JAPAN

- METHANOL AND SODIUM HYDROXIDE AT
300°C AND 180 Kg/cm² PRESSURE

2. LIQUID INDUSTRIAL WASTES

A) COWLEY CONSULTANTS LIMITED

- VAPOUR COMPRESSION DISTILLATION FOR
CONCENTRATION OF WASTES FOR RE-USE
- MINISTRY TO FUND ANALYTICAL TESTING
PROGRAM; \$40,000

B) CPW, BARRIE

- 'KING TECHNOLOGY' FOR THE ELECTRO-CHEMICAL
TREATMENT OF WASTES
- MINISTRY TO FUND ANALYTICAL TESTING
PROGRAM; \$30,000

WASTE SITE IDENTIFICATION STUDY

- DURING 1979, STUDY CONDUCTED BY:
 - YORK UNIVERSITY; SOUTHERN ONTARIO
 - LAURENTIAN UNIVERSITY; NORTHEASTERN ONTARIO
 - LAKEHEAD UNIVERSITY; NORTHWESTERN ONTARIO
- COST OF INVENTORY: \$98,000
- SOURCES OF INFORMATION:
 - MUNICIPAL OFFICIALS
 - MEDICAL OFFICERS OF HEALTH
 - HISTORICAL SOCIETIES
 - COUNTY RECORDS AND ANNALS
 - LONG-TIME LOCAL RESIDENTS
- SUMMARY REPORT TO BE ISSUED AT END OF JUNE, 1980
- TOTAL OF 1,451 SITES IDENTIFIED
 - 920 OF THESE WERE PREVIOUSLY KNOWN TO
 - MINISTRY BUT NOT CERTIFIED BECAUSE
 - THEY CLOSED PRIOR TO THE AUTHORIZING
 - LEGISLATION IN 1971
- APPROXIMATELY 170 SITES GIVEN PRIORITY I RATING FOR MORE DETAILED INVESTIGATION UNDER PHASE II OF STUDY TO BE INITIATED IN JULY AND COMPLETED BY OCTOBER
- QUALIFIED CONTRACTORS WILL INVESTIGATE WELL WATERS, SURFACE WATERS, ON-SITE METHANE GAS GENERATION AND GAS PRESENCE IN ADJACENT STRUCTURES
- ADDITIONAL WORK IS ALSO BEING UNDERTAKEN TO ATTEMPT TO LOCATE INDUSTRIAL WASTE DISPOSAL SITES ON COMPANY PROPERTIES WHICH MIGHT NOT HAVE BEEN IDENTIFIED IN THE EARLIER STUDY.

WAY-BILL MONITORING PROGRAM

- NEW WAY-BILL INTRODUCED IN JANUARY, 1979, PROVING TO BE A DEFINITE IMPROVEMENT
- STUDY COMPLETED ON OPTIMAL APPROACH TO HANDLING WAY-BILLS AND PROCESSING DATA
- AN 'INTELLIGENT TERMINAL' LOCATED IN WASTE MANAGEMENT BRANCH WILL BE USED TO INPUT DATA AND PRODUCE MINOR REPORTS, THIS WILL BE SUPPORTED BY THE GOVERNMENT MAIN COMPUTER FOR THE PRODUCTION OF MAJOR REPORTS AND STATISTICS.
- NEW SYSTEM TO BE IN PLACE THIS YEAR SUBJECT TO EQUIPMENT DELIVERY



Ontario

Ministry
of the
Environment

Transfers of Liquid Industrial Waste

Ontario Regulation 926/76

C 99883

Important: See Instructions on Reverse

SOURCE (Complete Section A Only. Please Print)

Company Name			
Waste Source Location		City/Town	
Waste Description: Check One.			
101 ☐ Acids	201 ☐ Oily Water	301 ☐ Pigments, Paint, Printing & Adhesives	
102 ☐ Alkalis	202 ☐ Waste Oils	302 ☐ Pesticides	
103 ☐ Metal Finishing Wastes	203 ☐ Organic Solvents	303 ☐ Detergents, Cleaners & Soaps	
104 ☐ Cyanides	204 ☐ Chlorinated Solvents	304 ☐ Pharmaceutical & Cosmetics	
105 ☐ Chemical Fertilizer Wastes	205 ☐ Plastic Resins	401 ☐ Plant & Animal Wastes	
106 ☐ Phosphates	206 ☐ Amines	402 ☐ Inert Sludges	
	207 ☐ Glycols		
	208 ☐ Phenols		
	209 ☐ PCB'S		
190 ☐ Other Inorganic (Specify)		290 ☐ Other Organic (Specify)	
Quantity		☐ Gallons	☐ Litres
Time Released	Day	Month	Year
Signature of Authorized Person			

RECEIVER (Complete Section B Only. Please Print)

Company Name		MOE Certificate of Approval No.	
Site Location		City/Town	
Transfer To:		Final	☐ Secure Landfill
or		Disposal	☐ Incineration
☐		By:	☐ Other (State Method)
Time Received	Day	Month	Year
Signature of Authorized Person			

CARRIER (Complete Section C Only. Please Print)

Company Name		Waste Mgmt System Number	
Address		City/Town	
Number		Street	
Vehicle License Plate Number		Signature of Driver	

MOE 1270 (7/79)

MINISTRY'S COPY

QUANTITIES OF LIQUID INDUSTRIAL WASTES GENERATED IN ONTARIO
(SUMMARY REPORT) JANUARY TO DECEMBER, 1979

<u>WASTE CLASSIFICATION</u>	<u>VOLUME (GALLONS)</u>
101 ACIDS	4,060,100
102 ALKALIS	1,746,000
103 METAL FINISHING WASTES	2,847,400
104 CYANIDES	41,700
105 CHEMICAL FERTILIZER WASTES	641,100
106 PHOSPHATES	262,000
190 OTHER (INORGANIC)	7,076,600
201 OILY WATER	14,542,000
202 WASTE OILS	2,477,800
203 ORGANIC SOLVENTS	2,839,200
204 CHLORINATED SOLVENTS	95,800
205 PLASTIC RESINS	1,094,900
206 AMINES	279,200
207 GLYCOLS	421,600
208 PHENOLS	503,700
209 PCB's	14,600
290 OTHER (ORGANIC)	3,991,000
301 PIGMENTS, PAINT, PRINTING AND ADHESIVES	3,184,300
302 PESTICIDES	216,000
303 DETERGENTS, CLEANERS AND SOAPS	402,000
304 PHARMACEUTICAL AND COSMETICS	22,000
401 PLANT AND ANIMAL WASTES	2,819,200
402 INERT SLUDGES	11,094,900
UNSPECIFIED	874,000
GRAND TOTAL	61,547,100

REGULATIONS AND GUIDELINES

I. REGULATIONS

4) MOVEMENT OF EQUIPMENT CONTAINING PCBs

- DRAFT COMPLETED AND APPROVED, WAITING FOR ADMINISTRATIVE GUIDELINES

5) WASTE OIL GUIDELINES

6) REGISTRATION OF WASTE

TYPES OF INDUSTRIES

METAL FINISHING

COSMETICS

PHARMACEUTICAL

TEXTILE

LABORATORIES

PETROLEUM & PETROCHEMICAL

FOOD

MUNICIPAL

CHEMICAL

WOODWORKING

LAUNDRY

STEEL MAKING

TANNERIES

PLASTICS

MISCELLANEOUS MANUFACTURING

BATTERY MANUFACTURING

PAINT MANUFACTURE

AUTOMOBILE MANUFACTURING

FOREST PRODUCTS

OVER 1,000 DIFFERENT SOURCES IDENTIFIED IN MINISTRY RECORDS

LIQUID INDUSTRIAL WASTES

DISPOSAL METHODS

1979

VOLUME
(MILLIONS OF GALLONS)

INCINERATION	19.0
--------------	------

LANDFILL	36.0
----------	------

EXPORT	5.0
--------	-----

MISCELLANEOUS	<u>1.5</u>
---------------	------------

TOTAL	61.5
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REGULATIONS AND GUIDELINES

1. REGULATIONS

- A) MOVEMENT OF EQUIPMENT CONTAINING PCBs
 - DRAFT COMPLETED AND APPROVED. WAITING FOR ADMINISTRATIVE GUIDELINES.
- B) REGISTRATION OF WASTES
 - STUDY COMPLETED OF APPROACH IN OTHER JURISDICTIONS THROUGHOUT WORLD
 - REGULATIONS EXPECTED TO BE DRAFTED BY END OF YEAR
- C) PROHIBITION ON LANDFILLING OF LIQUID WASTES
 - REGULATION IN ABEYANCE PENDING AVAILABILITY OF ALTERNATIVE TREATMENT AND DISPOSAL FACILITIES

2. GUIDELINES

- A) POLLUTION PREVENTION AND WASTE MANAGEMENT GUIDELINES FOR PCBs, NOVEMBER, 1978, TO BE REVISED.
- B) WASTE CLASSIFICATION GUIDELINES TO BE REVISED CONSISTENT WITH REGISTRATION OF WASTE REGULATION
- C) TREATMENT AND DISPOSAL OF LIQUID INDUSTRIAL WASTE GUIDELINE TO BE UPDATED OR CONVERTED INTO REGULATION
- D) WASTE OIL GUIDELINE TO BE REVISED PENDING POLICY ON ROAD OILING

PERPETUAL CARE PROGRAM

- TASK FORCE ESTABLISHED EARLY IN 1979
- TERMS OF REFERENCE TO ENSURE SOURCE OF FUNDING FOR SHORT-TERM AND LONG-TERM (AFTER CLOSURE) CONTINGENCIES AT LANDFILL SITES
- CONCLUDED THAT MEASURES REQUIRED IN:
 - A) OPERATIONAL SECTOR DURING OPERATION AND CLOSURE AND FOR SUBSEQUENT MONITORING AND MAINTENANCE
 - B) LIABILITY INSURANCE - OFF-SITE PROTECTION FOR THIRD PARTIES
 - C) CARE IN PERPETUITY - TO PROVIDE LONG-TERM MAINTENANCE AND PROTECTION AND FOR CONTINGENCIES NOT COVERED BY OTHER MEASURES.
- WORK WAS DELAYED PENDING REPORT FROM CONSULTANT ON AVAILABILITY OF INSURANCE.
- DETAILS NOW TO BE RESOLVED:
 - A) HOW CAN OWNERS OF SITES BE REQUIRED TO SECURE THE NECESSARY FUNDING?
 - B) WHAT IS REASONABLE LEVEL OF INSURANCE?
 - C) WHAT ARE REASONABLE SURCHARGES FOR THE ESTABLISHMENT OF PERPETUAL CARE FUND?
- REPORT EXPECTED TO BE FINALIZED BY END OF YEAR.

TRANSBOUNDARY MOVEMENT OF WASTES

- MINISTRY OF THE ENVIRONMENT AND ENVIRONMENT CANADA WORKING ON DEVELOPMENT OF A MANIFEST SYSTEM FOR INTERNATIONAL/INTER-PROVINCIAL MOVEMENT OF WASTES
- MOE REMAINS SUPPORTIVE OF 'OPEN BORDER' POLICY ON WASTE DISPOSAL
- MOE AND MICHIGAN RE-EVALUATING METHODOLOGY FOR AUTHORIZING WASTE TRANSFERS.
- CURRENTLY MOVEMENT OF WASTES IS:
 - ONTARIO TO U.S. - 500,000 GALS/MONTH
 - U.S. TO ONTARIO - 80-90,000 GALS/MONTH
- PCB SOLID WASTES MAY BE TAKEN TO U.S. SECURE LANDFILLS FOR DISPOSAL BY ONE CONTRACTOR IN CANADA. RECENT INDICATIONS ARE THAT THIS PERMIT MAY BE WITHDRAWN AS OF JULY 1, 1980.

SOME POSSIBLE MANAGEMENT PLANS FOR
THE TREATMENT/DISPOSAL OF
LIQUID INDUSTRIAL AND HAZARDOUS WASTES
IN ONTARIO

BY

J. W. MacLAREN
&
O. MARTINI

1. INTRODUCTION

Following a review of competitive proposals, Ontario's Ministry of the Environment retained James F. MacLaren Limited in March 1979 to prepare an overall management plan for handling the Province's liquid industrial and hazardous wastes in an environmentally acceptable manner. In preparing this management plan, the Ministry directed the Consultant to address the following topics:

- (a) existing management practices
- (b) current, and probable future, waste quantities
- (c) major concerns with present management practices
- (d) available technologies for improved management of wastes
- (e) identification of candidate regions within which treatment/disposal facilities might be located
- (f) alternative management systems

It was further identified that the Consultant would consider essentially all wastes which should not be disposed of in sewers, water courses, sanitary landfills, etc. All radioactive wastes were excluded from consideration. The study area was identified as the entire Province except for North Western Ontario since the latter formed part of a parallel Federal-Provincial study.

2. PRESENT MANAGEMENT PRACTICES

Currently, most hazardous and liquid industrial wastes are removed from the waste generators' sites by independent truckers in vacuum trucks having an average capacity of 11.3 m^3 (2,500 gallons) hauling up to 60 km (35 miles) one way; large volume generators are serviced by tractor-trailer systems carrying 22.7 m^3 (5,000 gallons) over 100 miles one way. At present, rail haulage does not play a significant role in the disposal of hazardous wastes but it is possible that this may change since truck haul costs continue to rise, often reaching levels of 1.5 to 2 cents per litre or 7 cents per gallon.

- 1979 population of Bavaria - approx. 11 million
- Quantity of "Special Wastes" - approx. 350,000 tonnes per yr.

The bulk of the Ontario wastes are generated in the following broad areas.

- (a) Windsor, Sarnia, London and their environs
- (b) The Kitchener-Guelph-Cambridge triangle
- (c) The Golden Horseshoe (Oshawa to Niagara).

It is estimated that some 10 to 20% of the wastes would be perceived as hazardous by most people with the balance (80 to 90%) being largely innocuous to human health. Examples of "hazardous" materials would be PCB's, banned pesticides, some acid solutions and compounds containing arsenic, mercury, beryllium and cyanides. Materials considered to be largely innocuous would include oil/water mixtures, paint sludges, metallic hydroxides and some organic solvents.

By making an allowance for unrecorded wastes that are currently stored on generators' properties plus additional wastes from new industries and/or increased future production, it is estimated that waste quantities could total 80 million gallons (400,000 tonnes) per year by 1985.

A review of historical data suggest that the foregoing total will include the following major categories of wastes:

- (i) lean organics mixtures containing
mostly oil and water 40% or 160,000 tonnes/yr
- (ii) non-halogenated organics such as
waste oils, paint sludges,
solvents, etc. 30% or 120,000 tonnes/yr
- (iii) halogenated solvents and compounds
containing PCB's <0.5% or 2,000 tonnes/yr
- (iv) spent caustics and other
alkalis 17% or 68,000 tonnes/yr

Most of Ontario's hazardous and liquid industrial wastes are currently treated and/or disposed by one or more of the following methods:

- (a) controlled discharge to municipal sewerage systems
- (b) co-disposal with solid wastes in some 20 to 25 sanitary landfills
- (c) product recovery with incineration of the residue (e.g. paint solvents)
- (d) export to facilities in United States (mainly New York, Ohio and Michigan)
- (e) incineration of non-halogenated organics at the Tricil Ltd. plant near Corunna
- (f) some chemical fixation in Hamilton, Ontario, by Frontenac Chemicals Ltd.
- (g) some suspected illegal dumping but it is believed that this quantity is limited.

Costs for these services vary widely depending on the treatment and disposal method used, the waste characteristics and volume, etc., but most range from 4 to 10 cents per litre or 18 to 50 cents per gallon.

3. CURRENT AND FUTURE WASTE QUANTITIES

A review of data generated by the Province's existing Way-Bill system, supplemented by discussions with major haulers and generators suggest that Ontario's industrial, commercial and institutional complexes generate in the region of 70 million gallons (350 000 metric tonnes) of liquid industrial and hazardous wastes per year at this time. On a population basis (Ontario has about 9 million people), these numbers are in line with statistics recently provided by the Lander of Bavaria in West Germany, thus (1)

(1) Defragger, F., Bavarian State Ministry for Development and Environment; private communication.

- | | | |
|------|--------------------------|--------------------------|
| (v) | spent acids | 12% or 48,000 tonnes/yr |
| (vi) | miscellaneous inorganics | <0.5% or 2,000 tonnes/yr |

It is believed that confidence in the foregoing quantities can be placed at approximately 15% $\pm$.

4. MAJOR CONCERNS WITH PRESENT PRACTICE

Four major concerns were identified with current waste disposal practice in Ontario, viz.

- (a) most months, 50% or more of the Province's hauled liquid industrial wastes are co-disposed in some 20 to 25 sanitary landfills. This practice poses a continuing threat to local groundwater regimes.
- (b) some 10% of the Province's wastes are now hauled to the U.S.A. for treatment and/or disposal (mainly to the States of New York, Ohio and Michigan). There is no guarantee that these borders will remain open indefinitely.
- (c) there are no "high temperature" incinerators in Canada suitable for destroying halogenated organics such as PCB's and banned pesticides.
- (d) for a variety of valid reasons, the private sector has not provided the necessary range facilities to properly manage all wastes generated in the Province.

With reference to item (d), the following facilities are urgently required to ensure that Ontario's industrial and hazardous wastes are properly managed in future:

- (i) a severe landfill for disposal of compounds of arsenic, lead, mercury, beryllium, etc. plus residues from pollution abatement facilities (e.g. metallic hydroxide sludges and wastes that have been chemically-fixed).

- (ii) a high temperature incinerator with appropriate emission control devices as noted in item (c) above.
- (iii) a physical chemical treatment complex where wastes such as oil-water mixtures, spent acids, spent alkalis, etc. could be neutralized and/or de-toxified.
- (iv) collection/storage depots for Northern and Eastern Ontario.

5. AVAILABLE TECHNOLOGIES

A review of European and North American practices in the field of industrial and hazardous waste management suggest the following to be viable, and existing technologies:

- reduction and treatment at the source with landfilling and/or incineration of any resulting residues
- secure landfills with leachate recovery
- incineration at "moderate" temperatures (750 to 800°C) of non-halogenated organics
- high temperature (1200°C or more) incineration on land or at sea for halogenated organics
- physical-chemical treatment processes for oil-water mixtures plus a variety of inorganic wastes (e.g. spent acid and alkali cleaners)
- solidification or chemical fixation (applicable to inorganic wastes mainly)
- recovery and re-use (e.g. oils and cleaning solvents) with incineration of residues
- interim storage in appropriately designed facilities
- deep well disposal into suitable geological formations with landfilling of pretreatment residues
- long-term storage in salt mines.

A number of technologies have been categorized as "experimental" or "emerging", including:

- vitrification
- microwave plasma reactors (Lockeed Corp. - California)
- plasma arc (R.M.C. - Kingston, Ontario)
- King technology of CPW, Barrie, Ontario (proprietary electro chemical treatment)
- chemical treatment for PCB's (University of Waterloo)
- destruction of PCB's in diesel engines (D. & D. Group and Ontario Research Foundation)

6. CANDIDATE REGIONS

From an analysis of results from the Ministry's Way-Bill system, it was determined that the majority of the liquid industrial wastes generated in Ontario originate in the area bounded by Oshawa on the east, Georgian Bay on the north and Windsor-Sarnia on the west. To establish waste treatment sites outside this section of the Province would create unique environmental and social risks to districts of the Province which have no interest or need for the service and at considerable additional transportation cost to those requiring the service.

It is proposed therefore that this designated district of the Province where most of the industrial wastes are generated, be analyzed through a process of overlay mapping to identify those regions that appear to contain sites which meet criteria relating to social concerns, earth sciences and hydrology.

As an example, social concerns might require the region containing a site opportunity to be more than 8 km from urban areas, and outside of Indian reservations, parks, conservation areas and prime agricultural land.

For earth sciences, as a further example, soil permeability, topography, geology and groundwater conditions would all be reviewed to set certain minimal criteria and any areas failing to satisfy these criteria would be eliminated from consideration on the overlay map of the district.

Surface water considerations such as site flooding potential and proximity to drinking water sources would produce further criteria to reduce the Provincial district to a reasonable number of regions in which site opportunities could be investigated.

It is recommended that this overlay or constraints mapping technique be initially undertaken on a regional basis using a "broad-brush" approach. The concept assumes that a designated region probably has within it, one or more areas that have potential for detailed site investigation even though a significant portion of that region may be unacceptable for site opportunities. The criteria suggested for use in carrying out a constraint mapping exercise as described above are summarized in Table 1.

Using the criteria summarized in Table 1, candidate regions shown in Figure 1 were identified. The "optimal areas" (shown in dark) exclude agricultural lands in Classes 1 to 4 of the Canada Land Inventory. The "minimal areas" (shown in grey) avoid Classes 1 and 2 but include Classes 3 and 4.

It should also be noted that use of the foregoing constraint mapping technique eliminates several major parcels of Government-owned lands from consideration because of their agricultural capability (e.g. properties near Cayuga and Pickering).

7. SOME POSSIBLE SYSTEM ALTERNATIVES

It was previously identified that Ontario has a requirement for the following key facilities:

CRITERIA FOR SELECTING CANDIDATE REGIONS

Category	Issue or Factor	Suitability for Siting		Comments
		Acceptable	Unacceptable	
Social/Cultural	Urban or densely pop. areas		Closer than 8 km to a built-up area	Further from populated area the better the site
	Recreational/Conservation areas		Areas designated or established as parks or open space	Condition set as above
	Agricultural areas	Avoid Canada land inventory Class 1,2,3,4 lands	Use of Class 1 and 2 lands	Class 1 and 2 lands critical
Earth Sciences	Transportation network	Access to 400 series highways desirable	Use of local streets	Major highway system best access route
	Topographic relief	Slopes 1% to 5%	Extreme flat or hilly terrain	Drainage problems with flat areas and siting problems in hilly areas
	Geology	Thick surficial deposits undisturbed sedimentary bedrock low seismic risk	Exposed bedrock highly fractured bedrock higher seismic risk	Maintenance of materials within the treatment area
Soils		Impervious clay/silt/loam materials easily worked, poor agricultural use	Pervious sands or gravels good agricultural land	Low permeability of soils key component
	Subsoils	Low permeability structurally unstable	High permeability structurally stable	Low permeability key as above
Groundwater		No aquifer recharge at site, deep water table, flow network in area established	Aquifer recharge at site, high water table, erratic or unknown flow network	Groundwater in site area to be protected

TABLE 1 (cont'd)

CRITERIA FOR SELECTING CANDIDATE REGIONS

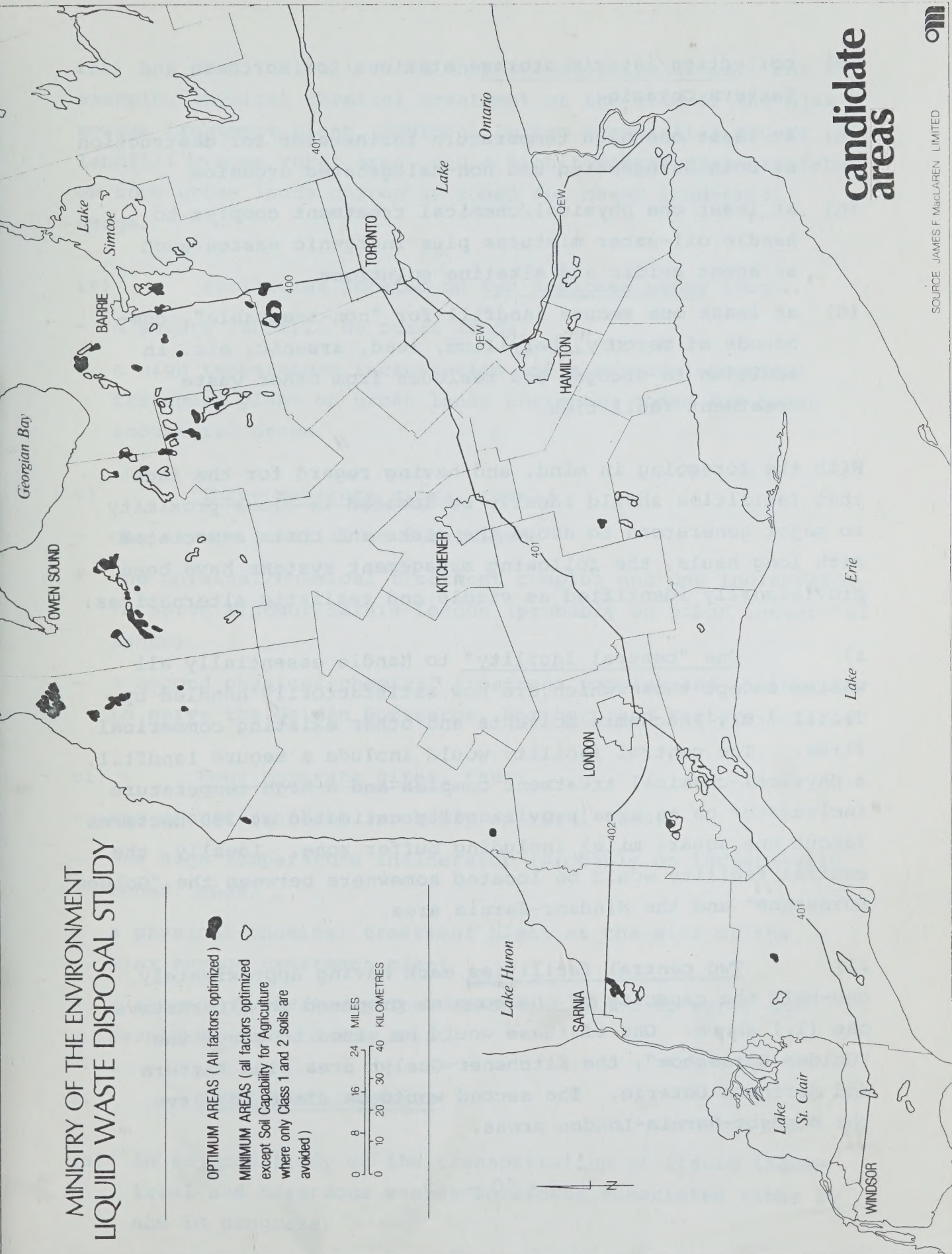
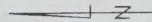
Category	Issue or Factor	Suitability for Siting		Comments
		Acceptable	Unacceptable	
Hydrology	Water supplies	Site remote from sources of water supplies	Site near to drinking water source	Drinking water supplies to be protected
	Major bodies of water or wetlands	Site not adjacent to major body of water or wetland area	Site adjacent to a multi-use water body or wetland area	Protection of water quality in the area
	Flooding	Site is above flood prone areas	Site in flood prone areas	Flood protection of site necessary
	Drainage	Good site drainage and control	Poor site drainage with no control	Avoid contamination of surface waters by containment of wastes

MINISTRY OF THE ENVIRONMENT LIQUID WASTE DISPOSAL STUDY

OPTIMUM AREAS (All factors optimized)

MINIMUM AREAS (all factors optimized
except Soil Capability for Agriculture
where only Class 1 and 2 soils are
avoided)

0 8 16 24 MILES
0 10 20 30 40 KILOMETRES



**candidate
areas**

- (a) collection/interim storage stations for Northern and Eastern Ontario
- (b) at least one high temperature incinerator for destruction of both halogenated and non-halogenated organics
- (c) at least one physical/chemical treatment complex to handle oil-water mixtures plus inorganic wastes such as spent acidic and alkaline solutions
- (d) at least one secure landfill for "non-treatable", compounds of mercury, beryllium, lead, arsenic, etc. in addition to sludges and residues from other waste treatment facilities.

With the foregoing in mind, and having regard for the fact that facilities should ideally be located in close proximity to major generators to avoid the risks and costs associated with long hauls, the following management systems have been provisionally identified as viable and realistic alternatives:

i) One "central facility" to handle essentially all wastes except those which are now satisfactorily handled by Tricil Ltd., Anachemia Solvents and other existing commercial firms. The central facility would include a secure landfill, a physical-chemical treatment complex and a high temperature incinerator on an area provisionally estimated at 250 hectares (about one square mile) including buffer zone. Ideally, the central facility would be located somewhere between the "Golden Horseshoe" and the Windsor-Sarnia area.

ii) Two central facilities each having approximately one-half the capacity of the complex proposed in alternative one (1.) above. One of these would be sited to serve the "Golden Horseshoe", the Kitchener-Guelph area plus Eastern and Northern Ontario. The second would be sited to serve the Windsor-Sarnia-London areas.

iii) Facilities located on three separate sites. For example, physical chemical treatment at the site of the Ajax sewage treatment plant (Regional Durham proposal) a secure landfill in some rural area, and a high temperature incinerator on some urban lands currently zoned for heavy industrial usage.

iv) Facilities located on two separate sites thus:

- a secure landfill on rural lands
- a high temperature incineration and a physical-chemical treatment plant on urban lands currently zoned for heavy industrial usage.

v) Three separate sites, thus:

- one secure landfill on rural lands
- one physical/chemical treatment complex and one incinerator to serve Windsor-Sarnia-London (probably on urban industrial lands)
- a second physical-chemical treatment complex and incinerator to serve the Golden Horseshoe, Northern and Eastern Ontario

vi) Four separate sites, thus:

- one secure landfill (probably on rural land)
- one high temperature incinerator (probably on industrially zoned lands)
- a physical-chemical treatment plant at the site of the Ajax sewage treatment plant
- a second physical-chemical treatment plant to serve the Sarnia-Windsor-London area.

8. CONCLUDING COMMENTS

- (a) An adjunct study on the transportation of liquid industrial and hazardous wastes including associated risks is now in progress.

- (b) Issuance of an interim summary on the management of liquid industrial and hazardous wastes has generated sufficient public response to suggest the need for a substantial public information program. A white paper in this regard is now being considered.
- (c) Various other combinations of the management systems listed in item 7 are, of course, possible.

HAZARDOUS WASTES STRATEGY FOR WESTERN CANADA

PRESENTED BY: EUGENE E. KUPCHANKO A.D.M., ALBERTA ENVIRONMENT

In September, 1979, Alberta Environment Minister, Jack Cookson, named a hazardous waste management committee to look into disposal of special wastes in Alberta, and propose recommendations for government action.

The committee was formed after a private company proposed a waste treatment plant near Edmonton and encountered resistance from citizens of the area.

One of the most controversial environmental problems of our society had begun to surface in Alberta. With the province moving to industrialization, the time was right to prevent the waste disposal problems found in many other areas. Concurrently with the activities in Alberta, Environment Canada, along with the Western Provinces, Northern Ontario, Yukon and the Northwest Territories embarked on a strategy for managing industrial waste in Western and Northern Canada. The first phase of this strategy was the hiring of Reid, Crowther and Partners to review hazardous waste quantities and assess the need for developing a coordinated hazardous waste management program.

The management and disposal of hazardous wastes presents a number of specific problems. The need for careful handling and safe disposal is not always fully recognized. The wide variety of waste types makes recognition of the particular danger of a given waste difficult for all but the expert.

A better quality of life is generally assumed to be the corollary of our technological wizardry. Unfortunately a by-product of this technology is waste, a good portion of which is hazardous in some respect.

The hazardous waste problem in this country and in the United States can be considered as one of the last environmental frontiers. The dimensions of this last frontier are so staggering as to be virtually incomprehensible. Involved are emotional issues of trying to regulate, control the use, and dispose of these wastes.

Hazardous Wastes is defined as any discarded material or combination of refuse and discarded materials which cannot safely and adequately be handled by existing waste management facilities because they pose a substantial, present or potential hazard to human health or other living organisms or the physical environment because of their chemical, biological or physical properties.

Hazardous wastes can be broken down into a number of categories:

1. Ignitable
2. Corrosive
3. Reactive
4. Toxic
5. Infectious
6. Bioaccumulative
7. Mutagenic, carcinogenic and teratogenic

It is readily apparent that the industrialization of northern and western Canada is concentrated within two provinces, Alberta and British Columbia.

Alberta has its primary industries - petroleum extraction and petroleum refining. Alberta generates approximately 89,000 tonnes of hazardous waste or 34 percent of the study region totals. (Table 1)

British Columbia has a greater diversity within its industrial base than does Alberta. In British Columbia, forestry, metal mining and manufacturing in addition to petroleum activities are major employers. British Columbia industries are responsible for the generation of 70,000 tonnes or 28 percent of the hazardous wastes.

What's The Problem?

A guide to some of Alberta's hazardous wastes.

WASTE TYPE	MAJOR GENERATION INDUSTRIES OR PROCESSES	EXAMPLES
Acids	Petroleum extraction and refining Textile industry Battery manufacturers Chemical industry Metal treating industry	Waste dye solutions Soluble and suspended lead wastes Pickling acids
Alkalis	Food industry Metal treating industry Chemical industry	Brewery caustic pulps Cleaning solutions
Contaminated Soil and Sand	All manufacturing industries Transportation industries	Rail car cleanout wastes
Solvents, Oils, Oil/ Solvent Mixtures	All manufacturing industries Transportation industries Petroleum and mining industries Utilities Municipal operations Laboratories	Lubricating oils Hydraulic oils Cooling oils
Pesticides	Chemical industry Application activities (municipal, agricultural, research)	Manufacturing effluents, tars, residues Banned stocks Empty container residues
Sludges	All manufacturing industries Petroleum industry	Pentachlorophenol sludge Oily sludges Heavy metal sludges
Pathological Wastes	Hospitals Medical and research laboratories	Infectious tissues, bandages Discarded specimens
Heavy Metal Solutions	Electroplating industries Metal treating Textile industry Plate engraving	Waste plating solutions Dye solutions Plate making solutions
Inks	Chemical manufacturing Printing operations	Manufacturing residues Ink wastes
Polychlorinated Biphenyls (PCBs)	Manufacturing industries Utilities	Transformer coolant fluids Out of service capacitors Soils and adsorbents contaminated by spills
Photographic Processing	Photo processors Printing industry Hospitals and research labs	Waste photographic processing solutions
Aqueous Chemical Wastes	Textile industry Chemical industry Manufacturing industries	Dye wastes Chemical sludges Metal plating and treating wastes Waste chemicals Process equipment rinses and cleaning wastes Reject chemical products
Hydrocarbon Chemical Wastes	Petroleum production Chemical industry	Pipeline pigging wastes Chemical blending wastes
Solid Chemical Wastes	Chemical industry Manufacturing industries Laboratories	Waste chemicals Chemical sludges

This information comes from a December, 1979, report on the economics of special waste management by Hu Harries and Associates Ltd.

Saskatchewan has historically been considered as an agricultural province. This is reflected in the number of dependent industries located there, particularly farm machinery. Saskatchewan is currently developing its oil and mineral resources. This will increase this province's contribution of hazardous waste from its present 44,000 tonnes or 18 percent.

Manitoba is dependent upon agriculturally-oriented industries and metal mining (primarily nickel). However, the textile and manufacturing industries make a significant contribution to the generation of waste in this province. In total 42,000 tonnes or 17 percent is generated here.

Northwestern Ontario has pulp and paper as its industrial mainstay. This region contributes 8000 tonnes or 3 percent of the total.

The Yukon and Northwest Territories are not developed to as large a degree as are the provinces' mineral extractive industries, the basis of the Northern economy. The Yukon and Northwest Territories are each responsible for generating approximately ten tonnes of hazardous waste.

Transporting waste materials from source to final disposal is an integral part of the overall waste management system. Careful examination of the transportation system is necessary to understand the capacity of that system to handle the existing waste loads in a safe and environmentally acceptable manner.

Most existing practices of hazardous waste collection and transport within the study area are far from adequate. There is no single reporting method used within the study area which can document a waste from the waste producer through to final disposal. Most firms handling the transportation of hazardous wastes have inadequate maintenance programs. Tank washing, for example, is conspicuously absent from the operations in many organizations. There are many other practices in the transportation

TABLE 1
WASTE GENERATION SUMMARY

WASTE CATEGORY	H.W. ONT. (tonnes)	MANITOBA (tonnes)	SASK. (tonnes)	ALBERTA (tonnes)	B.C. (tonnes)	YUKON (tonnes)	N.W.T. (tonnes)	N.W. CANADA (tonnes)
1. PCB	neg	10	neg	10	10	neg	neg	30
2. Oils	3,500	9,500	12,500	20,000	23,000	neg	neg	68,500
3. Halogenated solvents	N/A	700	200	900	2,100	neg	neg	3,900
4. Nonhalogenated solvents	400	100	20	5,600	700	neg	neg	6,820
5. Heavy Metal Solvents	neg	10	neg	neg	20	neg	neg	30
6. General Mixed Metal Bearing Sludge	100	600	500	5,000	2,400	neg	neg	9,600
7. Lead sludge	neg	neg	neg	neg	neg	0	0	neg
8. Chromium	0	500	60	100	60	0	0	720
9. Copper	0	neg	neg	neg	neg	0	0	neg
10. Aluminum	neg	40	neg	70	30	0	0	140
11. Magnesium	0	neg	0	0	0	0	0	0
12. Pesticides	0	neg	50	180	80	0	0	310
13. Textile Waste Treatment	0	10	10	10	40	0	0	70
14. Ink	N/A	10	neg	10	40	0	0	60
15. Organic tannery waste	0	9,600	12,800	2,100	1,000	0	0	25,000
16. Dust and Scrubber	0	20	30	90	100	0	0	140
17. Paint	neg	300	80	300	700	neg	neg	1,380
18. General Mixed Aqueous Metal Bearing Sludge	neg	neg	neg	50	30	neg	0	80
19. Acids with Heavy Metals	neg	500	40	500	500	neg	neg	1,540
20. Acids	10	900	2,200	23,700	14,100	neg	neg	50,910
21. Alkalis with heavy metals	0	50	10	70	40	neg	neg	170
22. Alkalis	10	2,200	3,600	5,500	5,200	neg	neg	16,510
23. Plastic, resins and latex	10	200	240	460	800	neg	neg	1,710
24. Phenols	neg	20	neg	60	50	neg	neg	130
25. Cyanides	neg	600	70	1,200	560	neg	neg	2,430
26. Phosphate Sludge	0	20	neg	10	20	0	0	50
27. Explosives	0	0	0	neg	neg	0	0	neg
28. Contaminated Containers & Equipment	10	20	10	460	400	neg	0	910
29. Contaminated Soil & Sand	10	1,800	400	2,500	2,500	neg	neg	11,010
30. Asbestos	neg	10	10	3,700	100	0	0	3,820
31. Ammonia	neg	neg	neg	10	10	0	0	20
32. Scrap Batteries	0	30	0	10	20	0	0	60
33. Waste Activated Carbon	neg	100	neg	40	100	0	0	240
34. Infectious Waste	200	900	930	1,200	N/A	neg	0	3,240
35. Tank Bottoms	40	500	720	1,300	1,200	neg	neg	3,760
36. Chemicals	neg	5,500	9,400	12,200	12,500	neg	neg	39,600
37. Sulphur	neg	80	120	200	20	0	0	420
38. Fly Ash	neg	300	20	150	300	neg	neg	770
39. Photo Chemicals	120	1,300	1,800	1,100	1,100	neg	neg	4,420
40. Spent Catalyst	neg	neg	neg	neg	neg	neg	neg	neg
TOTAL	4,400	37,000	46,000	89,000	70,000	neg	neg	246,400

N/A Not Available

neg. = negligible amount: less than 10 tonnes

Source - "Hazardous Wastes in Northern & Western Canada - The Need For a Waste Management Strategy" . . . Reid, Crowther & Partners Ltd.

industry that can be considered questionable. These include mixing of known waste types, concealment of hazardous wastes as normal waste, poor equipment maintenance, lack of training and safety awareness and the disposal of wastes in unsuitable areas.

Waste producers know the waste type, the transporter's identity, but not the location of disposal. The transporters are aware of the final disposal site for the waste but have limited knowledge of the waste type. The disposal site personnel are unaware of the characteristics relating to the waste being delivered and have sparse knowledge of the waste source. Within the total system there is an immediate need to document this information and to control the movement of the waste materials from source to final disposal.

The management of hazardous wastes requires a comprehensive approach to ensure that all of the components are considered. The components are as follows: (Figure 2)

- Waste Generation. The waste inventory details, the quantity of wastes, rates of generation, waste characteristics, degrees of hazards and sources of generation
- Transport System. The transport system should provide the mechanism for the collection, storage, transfer, and transport of wastes to processing and disposal facilities. The system capacity and the adequacy of practices to meet public health and environmental concerns are the key criteria.
- Treatment and Disposal System. The treatment and disposal system provides a mechanism for detoxification of wastes wherever possible and their safe disposal. The key criteria are system capacity, and the adequacy of environmental concerns.

• Government Control. Government control is necessary for each component of the system. The controls include legislation, regulation and the enforcement. The control component is perhaps the most important part of the system. All other parts cannot function effectively without systematic application of these controls.

• Monitoring. Monitoring is necessary to ensure compliance by the participants in the systems with the appropriate collection, treatment and disposal controls. Monitoring ensures a degree of protection for public health and environment, and provides the necessary observation from source to final disposal.

Along with the siting of a Hazardous waste disposal facility, transboundary movement of wastes is perhaps the most complex and controversial issue confronting hazardous waste policy makers. Public and political concern about future influx of wastes is puzzling in view of the current reality of transboundary movement of many hazardous chemicals. Interprovincial and international movement of hazardous chemicals is virtually unregulated, and significant quantities of these chemicals regularly move from one end of Canada to the other.

Increased public opposition to hazardous waste disposal facilities has brought social issues to the forefront. Indeed, many people involved in hazardous waste management now believe that social aspects create far more problems than the technical ones.

The major concerns which arise, in the order in which the public has emphasized them are:

- (a) effects on human health
- (b) effects on the environment

- (c) risk and safety
- (d) policy considerations
- (e) site planning factors
- (f) quality of life

Public opposition to the hazardous waste site rises when citizens do not perceive the facility as solving a local problem. They feel no need to solve a problem they did not create. The public perception is that the need to protect human health and the environment from hazardous wastes far outweighs the financial costs involved.

The credibility of the sponsoring agency is a critical factor in the public's acceptance of an agency's information. The agency's expertise and perceived trustworthiness are closely related to its credibility. If the public involvement and hearing process is seen closely allied with the approvals process, credibility is undermined.

One factor that influences social acceptability is the presence of useful information. The term "useful" refers to the audience for whom it was intended, not the agency which produces it. Typically, information about waste management is not understood by non-technical audiences because it is usually too complex; it focusses on engineering processes. The result is the generation of confusing and irrelevant information, seemingly designed to further public hostility.

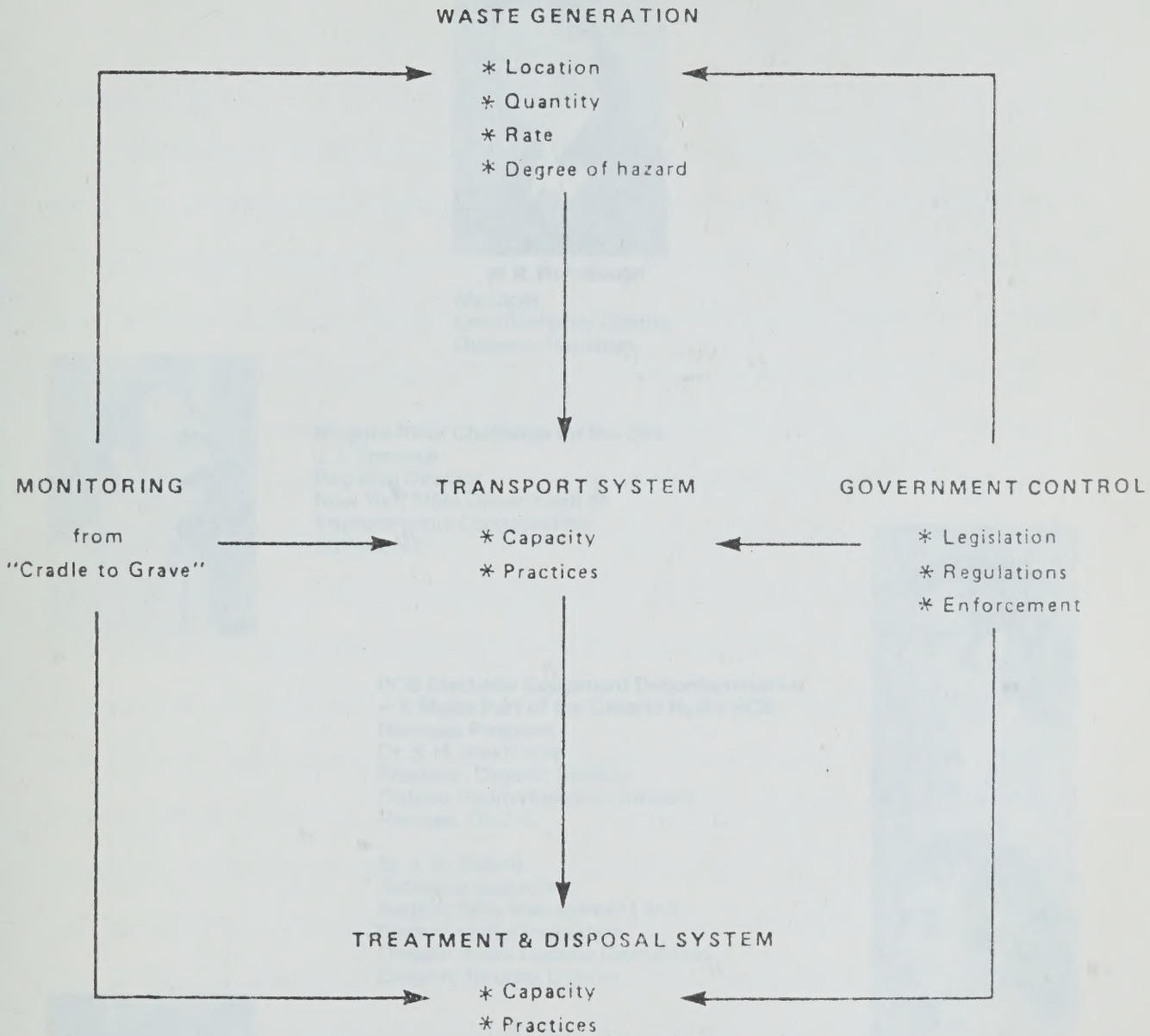
The media plays an important role in the dissemination and interpretation of information about hazardous waste management. In many cases, government agencies and proponents have treated media representatives with fear and suspicion. Ironically what government agencies and proponents often fail to recognize is that the general public will receive most of its information about hazardous waste management through the media. As a result conflicting

sources of information are established, and, in this case, the media is usually perceived as the more credible.

Hearings are presently being carried out by the Environment Council of Alberta on the Hazardous Waste Management Committee report.

We have now at last count 12 communities that have expressed an interest in a chemical waste disposal facility. They see in the facility job opportunities and growth for their community. However, they feel more comfortable if the Alberta Government participated directly in the facility.

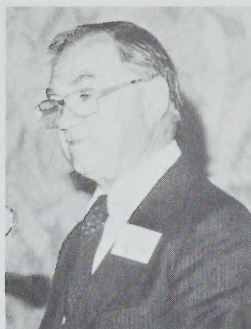
We all have a large role to play in special waste management both on technical and the ever increasing social issues. Hopefully, through proper waste management we will make your province and my province a better place to live.



A MODEL WASTE MANAGEMENT SYSTEM

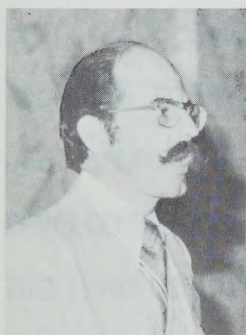
FIGURE 2

SESSION II
CHAIRMAN



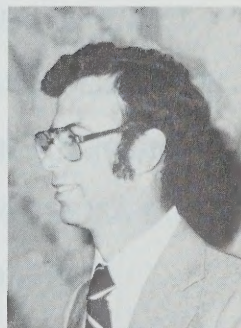
W. R. Rombough

Manager
Environmental Control
Dofasco, Hamilton



Niagara River Challenge for the 80's

J. J. Spagnoli
Regional Director
New York State Department of
Environmental Conservation
Buffalo, N.Y.

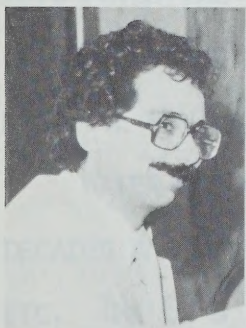


**PCB Electrical Equipment Decontamination
– A Major Part of the Ontario Hydro PCB
Disposal Program**

Dr. S. H. Hawthorne
Engineer, Organic Section
Ontario Hydro Research Division
Rexdale, Ontario



Dr. J. G. Ballard
Technical Supervisor
Radioactivity Management and
Environmental Protection
Ontario Hydro Nuclear Generation
Division, Toronto, Ontario



**Siting Hazardous Waste Disposal Facilities
– How to Prevent Law Suits and the "Not In
MY Back Yard" Syndrome**

David Estrin
Barrister & Solicitor
Eden Mills, Ontario

Note: Paper was read on behalf of Mr. Estrin
by Councillor Margaret Marland, City of
Mississauga



**The Political Realities of Environmental
Decision-Making in the 80's**

The Honourable Harry C. Parrott, D.D.S.
Ontario Minister of the Environment

JOHN J. SPAGNOLI
JOHN C. McMAHON

I. INTRODUCTION

THE NIAGARA RIVER AND ITS ASSOCIATED WATERSHED HAVE BEEN A FOCAL POINT FOR ENVIRONMENTAL ISSUES AND CONCERNS FOR SOME TIME. LOVE CANAL, IN-PLACE HAZARDOUS WASTE SITES, INDUSTRIAL EFFLUENTS, SCA/CECOS OPERATIONS AND THE NIAGARA FALLS SEWAGE TREATMENT PLANT ARE RECENT EXAMPLES OF PROBLEMS WHICH HAVE PRECIPITATED AND CONTINUED TO FEED CONTROVERSIAL DISCUSSIONS RELATING TO WATER QUALITY, ENVIRONMENTAL PROTECTION AND OVERALL RESOURCE USE. ALONG THE RIVER, NEW YORK STATE AND ONTARIO DIFFER IN THEIR USE AND DEVELOPMENT OF PERIPHERAL LAND AREAS. ONTARIO, HAVING CHOSEN TO DIRECT THE LAND USE TOWARDS RECREATIONAL WHILE NEW YORK PERMITTING THE LONG-TERM DEVELOPMENT OF INDUSTRIAL CENTERS. THESE CENTERS BEGAN WITH THE HYDRO-DEVELOPMENT OF THE RIVER AND HAVE GROWN AND PROSPERED DURING THE EARLY TO MID YEARS OF THIS CENTURY. WITH OUR PRESENT AWARENESS OF THE PAST MANUFACTURING PRACTICES, WASTE DISPOSAL METHODS AND LIMITED REGULATORY PROGRAMS, THERE IS NO DOUBT THAT THIS EASTERN SHORE HAS THE PROPENSITY TO ADD CONTAMINANTS TO THOSE ALREADY PRESENT IN THE INCOMING LAKE ERIE WATERS. THIS POTENTIAL COULD REMAIN UNCHECKED IF GOVERNMENTAL AGENCIES DO NOT CONTINUE TO ENHANCE AND IMPLEMENT REGULATORY ACTIVITIES DIRECTED TOWARD RESTRICTING NEGATIVE CONTRIBUTIONS TO ANY TRIBUTARY SYSTEM.

WATER POLLUTION AND SOLID WASTE CONTROLS HAVE EXISTED FOR SEVERAL DECADES AND HAVE ADDRESSED CLASSICAL ISSUES OF BOD, SUSPENDED SOLIDS, PH, ETC. THE 60'S IN PARTICULAR REFLECTED A DECADE OF PLANNING. COMPREHENSIVE SEWAGE AND SOLID WASTE STUDIES WERE UNDERTAKEN IN THE COUNTIES OF THE STATE. ALTERNATIVE PLANS FOR CONSOLIDATION OF FACILITIES WERE DEVELOPED AND ADOPTED.

WITH THE PASSAGE OF THE PURE WATERS BOND ACT OF 1965, DETAILED FACILITY PLANNING COMMENCED. IN 1970 WITH THE REDIRECTION OF THE DEPARTMENT OF HEALTH AND THE CREATION OF THE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, NEW YORK STATE SET THE STAGE FOR A MORE COMPREHENSIVE AND EFFECTIVE POLLUTION ABATEMENT PROGRAM. TO THIS END IN 1972, THE FUNDING OF THE PURE WATERS BOND ACT WAS AUGMENTED BY THE STATE ENVIRONMENTAL QUALITY BOND ACT. THAT SAME YEAR THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS (PL 92-500) WAS PASSED WHICH NOT ONLY REQUIRED ENHANCED WASTEWATER TREATMENT BUT ALSO INCREASED FEDERAL COST SHARING FOR PLANS AND INTERCEPTORS. HOWEVER, IT WAS NOT UNTIL 1974 THAT A STATEWIDE PROGRAM FOR TREATMENT WITH EMPHASIS ON SYNTHETIC ORGANIC WASTES STARTED TO TAKE SHAPE. THIS NEW DIRECTION WAS TO FURTHER AUGMENT THE EXISTING WATER POLLUTION ABATEMENT ACTIVITIES FOR WHICH IN THE NIAGARA FRONTIER OVER ONE BILLION DOLLARS HAS BEEN EXPENDED. WE ARE PRESENTLY OPERATING IN THIS MODE AND LOOK TO ENHANCEMENT OF THIS IMPETUS IN THE NEAR FUTURE.

II. PROBLEM

THE NIAGARA RIVER RECEIVES WASTE CONTRIBUTIONS FROM THE WATERSHED IN ADDITION TO THAT WHICH IS PRESENT IN THE WATER AT ITS POINT OF ENTRY FROM LAKE ERIE. THE SPECIFIC EFFLUENT POINTS ARE MANY AND THEIR CONTAMINANTS VARY. THESE UNDESIRE COMPOUNDS DEGRADE WATER QUALITY AND MAY LIMIT ITS USE. FURTHERMORE SOME HAVE SHOWN A PROPENSITY TO EITHER KILL AQUATIC LIFE FORMS OR BIOACCUMULATE IN THE TISSUES AFFECTING SOME BODY PROCESSES. IN THOSE INSTANCES WHERE CONTAMINATION MAY NOT BE PRESENT IN HIGH ENOUGH CONCENTRATION TO AFFECT THE RESOURCE, IT STILL MAY AFFECT THE RESOURCE USE BY RESTRICTING CONSUMPTION. IN ALL INSTANCES AND FOR ALL SITUATIONS IT IS DESIRABLE TO LIMIT NEGATIVE CONTRIBUTIONS TO ANY AQUATIC SYSTEM. THEREFORE, A KNOWLEDGE OF ALL WASTE SOURCES IS ESSENTIAL FOR THE

DEVELOPMENT OF ANY LONG-TERM REMEDIAL PLAN FOR ENHANCE OF THE WATERWAY.

A. MUNICIPAL FACILITIES

ALL MAJOR POPULATION CENTERS ADJACENT TO LAKE ERIE AND THE NIAGARA RIVER ARE NOW SERVED BY MUNICIPAL FACILITIES. TO DATE MOST ARE PROVIDING SECONDARY TREATMENT AND HAVE CAPACITY FOR PHOSPHOROUS REMOVAL. THOSE SYSTEMS WITH INDUSTRY HAVE IN THE PAST PERMITTED INDUSTRIAL TIE-INS AND NOW TREAT A MIXED EFFLUENT. THIS SLIDE LISTS THE 11 MAJOR FACILITIES WHICH SERVE THE 1.3 MILLION PEOPLE AND TRIBUTARY INDUSTRIES IN ERIE AND NIAGARA COUNTIES. OF PARTICULAR INTEREST IS THE WASTEWATER FACILITY SERVING THE CITY OF NIAGARA FALLS. THIS WASTEWATER TREATMENT PLANT IS AN ADVANCED WASTE TREATMENT FACILITY WITH A DESIGN FLOW OF 48 MGD. TREATMENT PROVIDED INCLUDES CHEMICAL FLOCCULATION, COAGULATION, SEDIMENTATION, PH ADJUSTMENT, CARBON FILTRATION AND CHLORINATION. THIS PLANT STARTED TO RECEIVE FLOW IN APRIL OF 1977, HOWEVER, SEVERAL PROBLEMS DEVELOPED SINCE START-UP. THE CARBON BEDS WHICH CONSTITUTE THE ADVANCED TREATMENT ELEMENT FAILED DUE TO CORROSION OF THE SUPPORTING STEEL IN THE BOTTOM OF THE BED. THIS CAUSED THE BED SUPPORT PLATES TO BUCKLE UNDER THE BACKWASH PRESSURE.

AN INVESTIGATION AND REMEDIAL PLAN HAS BEEN COMPLETED. FINAL RESTORATION IS IMMINENT WITH COMPLETION IN ABOUT ONE YEAR. HOWEVER, DURING THE HIATUS OF INCOMPLETE TREATMENT, THE FACILITY CONTINUES TO OPERATE WITH ALL OTHER UNITS AND IS CAPABLE OF ACHIEVING $\pm 60\%$ REMOVAL OF WASTE INCLUDING SYNTHETIC ORGANICS. AN ADDITIONAL PROBLEM ENCOUNTERED IN THE FACILITY IS ABOVE AVERAGE DRY WEATHER FLOWS OF 65 MGD AS COMPARED TO A DESIGN OF 48 MGD. STUDIES ARE UNDERWAY TO IDENTIFY EXTRANEOUS FLOWS TO THE SYSTEM.

B. INDUSTRIAL FACILITIES

DIRECT INDUSTRIAL DISCHARGERS HAVE ALSO BEEN THE SUBJECT OF COMPLIANCE ACTIONS DURING THE PAST DECADE. FEDERAL DISCHARGE LIMITATIONS BASED ON THE UTILIZATION OF BEST PRACTICABLE TREATMENT PLUS THE REQUIREMENT TO MEET STATE WATER QUALITY STANDARDS HAS RESULTED IN EXPENDITURES FOR INDUSTRIAL WATER POLLUTION CONTROL IN ERIE AND NIAGARA COUNTIES IN THE AMOUNT OF ABOUT \$230 MILLION. AT THE PRESENT TIME IT IS OUR BELIEF THAT THERE IS GENERAL COMPLIANCE BY THE DIRECT INDUSTRIAL DISCHARGERS WITH APPLICATION OF BEST PRACTICABLE TREATMENT REQUIREMENTS. THE FOLLOWING 2 SLIDES REFLECT THE MAJOR INDUSTRIES AND INDICATES THE MAJOR PARAMETERS OF CONCERN IN THEIR EFFLUENTS.

FURTHERMORE, EFFORT IS BEING EXPENDED BY SOME INDUSTRIES TO ADDRESS INFILTRATION -- INTO OLD SEWER LINES -- OF MATERIALS WHICH HAVE CONTAMINATED PERIPHERAL SOIL NEAR AND AROUND PIPE JOINTS OR BREAKS. THESE CONTAMINANTS ENTER THE SEWER PARTICULARLY DURING PERIODS OF HIGH PRECIPITATION. BECAUSE OF THIS PROBLEM EFFLUENTS FROM SOME INDUSTRIES REMAIN MARGINAL DESPITE EFFORTS TO ADEQUATELY TREAT PROCESS WASTES.

C. IN-PLACE HAZARDOUS WASTE SITES

THE INTERAGENCY TASK FORCE ON HAZARDOUS WASTES WAS CREATED IN AUGUST OF 1978 AS A RESPONSE TO A GROWING AWARENESS OF THE DANGER OF ABANDONED HAZARDOUS WASTE DISPOSAL SITES IN ERIE AND NIAGARA COUNTIES. THE GROUP WAS CHARGED WITH THE RESPONSIBILITY FOR DETERMINING THE SOURCE, NATURE AND LOCATION OF HAZARDOUS WASTE SITES IN THE TWO COUNTIES. AS A RESULT OF THEIR WORK, 215 SITES WERE IDENTIFIED INCLUDING: 125 INDUSTRIAL WASTE SITES OWNED BY WASTE GENERATORS, 84 MUNICIPAL, STATE OR PRIVATE WASTE DISPOSAL SITES, 6 FEDERAL DISPOSAL SITES. WITHIN THIS GROUP 36 WERE GIVEN PRIORITY I RATINGS (DEFINITELY RECEIVED LARGE QUANTITIES OF HAZARDOUS WASTES); 116 CLASSIFIED AS PRIORITY II (MAY HAVE RECEIVED SIGNIFICANT QUANTITIES OF HAZARDOUS WASTES); AND 61 WERE ASSIGNED

PRIORITY III (UNLIKELY TO HAVE RECEIVED SIGNIFICANT QUANTITIES OF HAZARDOUS WASTES). THIS SLIDE REFLECTS THE LOCATION OF THE SITES. A RECENT INVESTIGATION IN THE OTHER 4 COUNTIES OF THE WATERSHED HAS ADDED ABOUT 50 ADDITIONAL SITES TO THIS LIST. I HAVE SELECTED THE MORE SIGNIFICANT OF THESE SITES AND DEPICTED THE AVAILABLE INFORMATION ON THE FOLLOWING SLIDES:

(FOR ALL SITES GIVE HISTORY, PRESENT STATE & PROGNOSIS)

HOOKEr Co. - LOVE CANAL

duPONT - NECCO PARK

HOOKEr Co. - HYDE PARK

duPONT - BUFFALO AVE. PLANT SITES

HOOKEr Co. - S & N AREAS

WHEATFIELD LANDFILL

HOOKEr Co. - D & F AREAS

LANCASTER LANDFILL

HOOKEr Co. - 102ND STREET

FRONTIER CHEMICAL - PENDLETON SITE

HOOKEr Co. - DUREZ

CECOS - NIAGARA FALLS FACILITY

OLIN - 102ND STREET

SCA - PORTER FACILITY

ALL OF THESE SITES CONTAIN WASTES WHICH ARE HAZARDOUS TO HUMANS OR THE ENVIRONMENT. WITH FEW EXCEPTIONS THE WASTES WERE DISPOSED OF WITHOUT CONCERN FOR FUTURE MIGRATION AWAY FROM THE DUMP AREA. CONSEQUENTLY, WE ARE NOW AWARE THAT FOR THE MOST PART THE AFOREMENTIONED SITES ARE CONTAMINATING GROUND WATER OR HAVE THE PROPENSITY TO CONTAMINATE GROUND WATER. NOTING THE DIRECTION OF THE FLOW, ITS RATE THROUGH THE IMMEDIATE SOILS AND ADJACENT ROCK STRATA, IT IS REASONABLE TO SURMISE THAT A FEW SITES HAVE BECOME SOURCES OF INDUSTRIAL CONTAMINATION TO THE NIAGARA RIVER. THE IMPACT FROM THESE UNIQUE AND LONG-TERM NON-POINT SOURCES IS BEING INVESTIGATED.

D. Non-Point Sources and Accidental Spills

IT IS IMPOSSIBLE TO QUANTIFY THE CONTRIBUTIONS FROM NON-POINT OR ACCIDENTAL SOURCES. DATA FROM STUDIES ON URBAN, SUBURBAN OR AGRICULTURAL WATERSHEDS SUGGESTS A DIVERSITY OF COMPONENTS TO A DEGREE RELATED TO THE USES OF THE WATERSHED OR THE INDUSTRIES OPERATING IN THE AREA. THERE IS NO QUESTION THAT RUNOFF WATER FROM NIAGARA FALLS, SOUTH BUFFALO OR LACKAWANNA PROBABLY CONTAINS CONTAMINANTS ASSOCIATED WITH INDUSTRY AS AGRICULTURAL RUNOFF HAS BEEN SHOWN TO CONTAIN TRACES OF PESTICIDES USED.

IN ALL OF THE AFOREMENTIONED CASES KNOWLEDGE OF THE EFFLUENT AND ITS COMPONENTS IS IMPERATIVE IN ADDRESSING NOT ONLY THE QUALITY OF THE SPECIFIC EFFLUENT, ITS IMPACT ON THE RECEIVING STREAM BUT ALSO IS USABLE AS A BACK-TRACKING MECHANISM TO LOCATE THE SOURCE OF AN UNDESIRABLE PARAMETER OF CONCENTRATION NOTED IN WATER OR BIOTA SAMPLING.

III. CONTROL STRATEGY

THE DEPARTMENT OF ENVIRONMENTAL CONSERVATION IS DIRECTED BY MANDATE TO ". . . CONSERVE, IMPROVE AND PROTECT ITS NATURAL RESOURCES AND ENVIRONMENT AND CONTROL WATER, LAND AND AIR POLLUTION . . ." IT IS OUR OBJECTIVE TO MEET THIS MANDATE WITH REGULATORY PROGRAMS OF BOTH STATE AND FEDERAL ORIGIN. OUR INCREASED ACTIVITIES SHALL BE DIRECTED TO THE HAZARDOUS PORTION OF ANY EFFLUENT CONSISTENTLY ATTEMPTING TO PRECLUDE THOSE CONTRIBUTIONS WHICH HAVE A PROPENSITY TO IMPACT ON HEALTH AND THE ENVIRONMENT.

THE STATE IS GIVING HIGH PRIORITY AND PROGRAM EMPHASIS TO AN OVERALL STRATEGY TO CONTROL HAZARDOUS WASTES. OUR PRESENT EMPHASIS IS TO ADDRESS IN-PLACE PROBLEMS BUT WE ARE ACTIVELY INVOLVED IN ACTIVITIES WHICH WILL PRECLUDE NEW CONTRIBUTIONS. THESE ACTIVITIES ARE INTERDISCIPLINARY IN NATURE AND INCLUDE PARTICIPATION BY BOTH THE ENGINEERING AND NATURAL RESOURCE DIVISIONS. THE STRATEGIES DEVELOPED ARE REVIEWED WITH EPA TO ASSURE DIRECT COMPATIBILITY WITH THE MYRIAD OF FEDERAL LAWS AND REGULATIONS SINCE NEW YORK STATE DESIRES TO CONTINUE TO RECEIVE DELEGATIONS FOR THE IMPLEMENTATION OF FEDERAL PROGRAMS. ADDITIONALLY, WE DO NOT WISH TO PROMULGATE STRATEGIES THAT CONFLICT WITH NATIONAL POLICY.

PRESENT ACTIVITIES WITH MAJOR IMPACT ON THE NIAGARA RIVER INCLUDE:

A. PRETREATMENT PROGRAMS

ALL MUNICIPAL SEWAGE TREATMENT PLANTS WITH A DESIGN FLOW GREATER THAN 5 MGD MUST INITIATE AND ENFORCE AN INDUSTRIAL PRETREATMENT PROGRAM IN ACCORDANCE WITH FEDERAL REGULATIONS. NEW YORK STATE DEC

WILL ASSUME RESPONSIBILITY TO OVERVIEW THE PROGRAM. THE KEY DATE FOR BOTH MUNICIPALITIES AND INDUSTRIES IS JULY 1, 1983. CATEGORICAL EFFLUENT LIMITS FOR 129 PRIORITY POLLUTANTS WILL BE ESTABLISHED BY EPA FOR 21 INDUSTRIAL CATEGORIES. AT THE PRESENT TIME FIVE OF THE 11 FACILITIES MENTIONED ABOVE HAVE PRETREATMENT PROGRAMS UNDERWAY. THEY INCLUDE:

BUFFALO SEWER AUTHORITY	CITY OF NORTH TONAWANDA
TOWN OF TONAWANDA	CITY OF NIAGARA FALLS
TOWN OF AMHERST	

SOME SMALLER PLANTS WITH DESIGN FLOWS LESS THAN 5 MGD WILL REQUIRE A PRETREATMENT PROGRAM IF INDUSTRIES PROVIDE A SIGNIFICANT PORTION OF THEIR DAILY FLOW.

B. SPDES PERMIT SYSTEM

SINCE 1972, FEDERAL REGULATIONS HAVE REQUIRED A POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT FOR REGULATION OF DISCHARGES FROM POINT SOURCES. THE INITIAL PERMITS WERE FEDERAL BUT ISSUANCE IS NOW DELEGATED TO NEW YORK STATE. THIS REQUIRES THAT ALL INDUSTRIAL AND MUNICIPAL WASTEWATERS MUST MEET SPECIFIED EFFLUENT STANDARDS IN ADDITION TO SURFACE WATER STANDARDS. INDUSTRIAL EFFLUENT LIMITS ARE DESIGNATED BY INDUSTRIAL CATEGORY AND PRESENT RESTRICTIONS ARE BASED ON BPT (BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE). BY 7/1/84 INDUSTRY WILL BE REQUIRED TO PROVIDE BAT (BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE) AS A MINIMUM TREATMENT FOR POLLUTANTS INCLUDING TOXIC WASTES. MUNICIPAL FACILITIES MUST PROVIDE SECONDARY TREATMENT BY 7/1/83.

ANALYTICAL TECHNIQUES AND TREATABILITY DATA FOR THE 129 PRIORITY CHEMICALS IS BEING SUPPLIED BY THE USEPA.

C. INVENTORY PROGRAM

PRIMARY ACTIVITIES BEING UNDERTAKEN FOR THIS TASK INCLUDE THE STATEWIDE INDUSTRIAL CHEMICAL SURVEY, STATEWIDE INVENTORY OF INDUSTRIAL HAZARDOUS WASTES, AND ASSESSMENT OF AIR AND WATER EFFLUENTS. INFORMATION GATHERED IS USED TO IDENTIFY PRIORITY SITES, PREPARE PERMITS LIMITING THE DISCHARGE OF TOXIC SUBSTANCES AND IN THE IDENTIFICATION OF ENVIRONMENTAL HOTSPOTS. INFORMATION ON TOXIC AND HAZARDOUS WASTE GENERATORS, HAULERS AND DISPOSAL SITES WITH VOLUMES AND CHARACTERISTICS WILL SERVE AS THE BASIS FOR FUTURE HAZARDOUS WASTES REGULATORY ACTIVITIES.

D. MONITORING PROGRAM

THE STATE HAS HISTORICALLY MONITORED EFFLUENTS AND WATERWAYS FOR CLASSICAL POLLUTANTS. DURING THE PAST SEVERAL YEARS NEW APPROACHES TO MONITORING HAVE BEEN IMPLEMENTED WHEREIN TOXIC SUBSTANCES HAVE TAKEN PRIORITY OVER PREVIOUS PARAMETERS. THE RE-ORIENTATION CONTINUES WITH THE FOLLOWING PROJECTED FEATURES:

- . NPDES/SPDES PERMITS WILL BE MODIFIED TO INCLUDE PARAMETERS FOR HAZARDOUS/TOXIC SUBSTANCES.
- . EPA AND DEC WILL INSURE THAT A HIGH PRIORITY IS GIVEN TO STEP 1 GRANTS TO MUNICIPALITIES TO CONDUCT SURVEYS OF INDIRECT INDUSTRIAL SOURCES OF TOXIC POLLUTANTS.
- . DEC WILL INSURE THE DEVELOPMENT OF ADEQUATE HAZARDOUS WASTE AND SANITARY LANDFILL SELF-MONITORING PROGRAMS.
- . DEC AND EPA WILL EXPAND COMPLIANCE MONITORING INSPECTIONS.
- . EPA WILL ENCOURAGE THE CORPS OF ENGINEERS TO ESTABLISH A TOXICS MONITORING PROGRAM IN AREAS OF MAJOR HARBOR MAINTENANCE.

- . TRACKDOWN SURVEYS WILL BE INCREASED UTILIZING WATER QUALITY OR BIOASSAY DATA AS A BASE.
- . MOBILE BIOASSAY WILL BE ENHANCED FOR EFFLUENT MONITORING.
- . BIOASSAY WILL BECOME A MORE FREQUENT PARAMETER IN INDUSTRIAL EFFLUENT PERMITS.
- . THE EXISTING TOXIC SUBSTANCES MONITORING PROGRAM UTILIZING FISH AS A BIOMONITOR WILL BE EXPANDED.
- . DEC, MINISTRY OF THE ENVIRONMENT AND ENVIRONMENT CANADA ARE PRESENTLY MEETING TO DISCUSS THE FEASIBILITY OF A MUTUAL RIVER MONITORING PROGRAM WITH EMPHASIS ON TOXIC SUBSTANCES.

E. IN-PLACE TOXIC SUBSTANCES REMEDIAL WORK

THE DEPARTMENT OF ENVIRONMENTAL CONSERVATION HAS DEVELOPED AND IS IMPLEMENTING A STRATEGY TO ADDRESS THE INPLACE HAZARDOUS WASTE SITES. IT IS THE OBJECTIVE OF THIS STRATEGY TO PRECLUDE FURTHER MIGRATION OF CONTAMINANTS TO THE PERIPHERAL ENVIRONMENT. AS OF THIS DATE ACTION HAS BEEN INITIATED ON ALL PRIORITY ONE SITES. MANY ARE NOW IN SOME STATE OF REMEDIAL WORK. IN TIME PRIORITY TWO SITES WILL BE ADDRESSED. TO THE EXTENT POSSIBLE NEW YORK STATE IS DIRECTING THE LANDOWNER TO ASSUME RESPONSIBILITY FOR THE WORK. HOWEVER, CONSIDERING THE COST OF REMEDIAL ACTIVITIES IT CAN BE EXPECTED THAT RESISTENCE AND LEGAL ACTION WILL BE REQUIRED WHERE OWNERSHIP IS IN QUESTION.

IV. FUTURE

THE NIAGARA FRONTIER BEING ONE OF THE MOST INDUSTRIALIZED AREAS OF NEW YORK STATE AND THE CENTER FOR PETRO-CHEMICAL ACTIVITIES HAS BEEN SHOWN TO HAVE A CONCENTRATION OF POLLUTION PROBLEMS. THIS REGION PRESENTLY HAS THE DUBIOUS HONOR OF HAVING ABOUT 50% OF NEW YORK STATE'S TOXIC OR HAZARDOUS WASTE PROBLEMS. CONSEQUENTLY, IT HAS BECOME A PRIORITY AREA FOR ACTION DURING THE 1980'S. NOT ONLY IS THE STATE DIRECTING ADDITIONAL RESOURCES TO

THIS WATERSHED BUT THE REGION IS STARTING TO SHIFT PRIORITIES TO ENHANCE TOXICS MANAGEMENT. FOR THE MOST PART MANAGEMENT IS FEASIBLE. POINT SOURCES AND INPLACE HAZARDOUS WASTE AREAS WILL REQUIRE A CONSIDERABLE AMOUNT OF TIME AND EFFORT TO ADDRESS. NEW TECHNIQUES FOR RESTRICTING THE MIGRATION OF CONTAMINANTS FROM DUMPS WILL BE DEVELOPED, WASTEWATER TREATMENT PROCESSES WILL BECOME MORE EXACT REQUIRING GREATER PRECISENESS. NEW LEGISLATION RELATIVE TO HAZARDOUS WASTE TRANSPORTATION, STORAGE AND DISPOSAL WILL MANDATE GREATER CONTROL AND BE A CATALYST FOR INNOVATIVE TECHNOLOGY.

THE IMPROVEMENTS MADE IN ALL MEDIA -- AIR-LAND-WATER -- OF THE NIAGARA WATERSHED WILL RESULT IN A HIGHER STANDARD OF LIVING FOR THIS SHARED RESOURCE.

PCB Electrical Equipment Decontamination
- A Major Part of the Ontario Hydro
PCB Waste Management Program

by

S.H. Hawthorne

and

J.G. Ballard

INTRODUCTION

One of the major uses of polychlorinated biphenyls has been as a dielectric fluid in power transformers and power factor correction capacitors. Fluids containing PCB's have been used in this type of equipment since the 1930's. These fluids are commonly called "Askarels".

In recent years production and use of PCB's in manufacturing and processing has stopped in North America. Although these actions have alleviated to some extent the concern that the environment may be further contaminated with PCB's, the task of managing existing stocks of PCB's, and PCB contaminated materials, in an environmentally safe manner still remains.

In January 1978 as part of a program to provide environmentally safe PCB management options, Ontario Hydro set out to develop techniques to safely manage waste PCB's owned by the Corporation. This program included both the treatment of PCB fluid, and solid material contaminated with PCB.

To date, the major emphasis of attempts by industry, the Federal Government and the Provincial Government to develop safe management methods for PCB's has been in respect of PCB fluids and PCB contaminated oil. Little effort has been devoted to developing methods for solid material contaminated with PCB.

This paper is intended to illustrate some of the problems associated with management of solid waste, to describe some of the options presently being evaluated by Ontario Hydro and to report on the results of a project undertaken by the Corporation to demonstrate the feasibility of solvent cleaning of transformers and capacitors.

PCB SOLID WASTE

PCB solid waste material is any solid material which has come in contact with PCB fluid through its use as a dielectric fluid, or as a result of loss of PCB fluid from equipment. The majority of solid waste material generated by Ontario Hydro, falls into the former category. This waste is generally in the form of whole capacitors and drained transformers.

Capacitors are sealed steel cases with paper, aluminum foil and polypropylene internals. A large proportion of the PCB's in these units is impregnated in, or adsorbed on, the internals and cannot be removed by draining.

The drained transformers are steel cases containing a laminated steel core wrapped with copper wire and paper. These transformers range in size from small potential transformers containing 30 L of askarel, to large exciter transformers containing up to 10 m³ of askarel and weighing about 20 000 kg drained.

Any facility designed to store, decontaminate or dispose of this material must have the capability of handling not only a large volume of solid material of this type, but also these very large individual pieces of equipment.

MANAGEMENT OPTIONS

The investigation of management options for PCB solid waste was approached with a number of objectives in mind. The methods must:

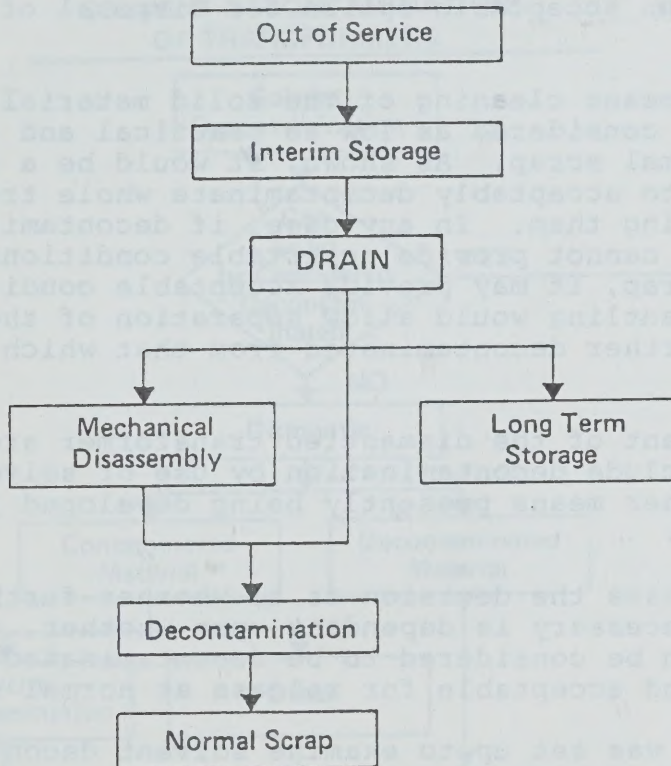
- minimize loss of PCB to the environment
- minimize occupational exposure to PCB's by minimizing handling of PCB contaminated solids
- maximize to the extend practical the removal of PCB's from the solid waste material

Transformers

The management options for transformers are outlined in Figure 1. Transformers brought out of service are sent to interim storage where they are drained of as much of the PCB fluid as possible. These units are then ready for disposal.

The initial approach to disposing of transformers involved investigating methods to mechanically disassemble and decontaminate whole transformers. The main reason for this was that manually dismantling transformers is a labour intensive job which could potentially involve exposure of employees to PCB's.

FIGURE 1
PCB FILLED TRANSFORMERS



Mechanical disassembling the transformers and subsequently decontaminating the parts is not considered practical. The majority of the PCB filled transformers owned by Ontario Hydro are large and we believe it would be extremely difficult to devise a facility which could mechanically disassemble the cores efficiently, economically, and with acceptable working conditions for employees.

Interim and long term storage implies either storage of contaminated equipment for a period of time until ultimate disposal options are available, or permanent storage. This type of storage may be above or below ground in engineered storage structures. It is the present policy of Ontario Hydro to provide safe interim storage, but permanent storage of this material is not considered an acceptable option for disposal of PCB solids.

"Decontamination" means cleaning of the solid material to a level which can be considered as low as practical and acceptable for release as normal scrap. As shown, it would be a desirable option to be able to acceptably decontaminate whole transformers without disassembling them. In any case, if decontamination of whole transformers cannot provide acceptable conditions for disposal as normal scrap, it may provide acceptable conditions for dismantling. Dismantling would allow separation of the material which cannot be further decontaminated from that which can be decontaminated.

Options for treatment of the dismantled transformer are given in Figure 2. They include decontamination by use of solvent, incineration or other means presently being developed for treatment of PCB wastes.

In each of these cases the decision as to whether further decontamination is necessary is dependent upon whether, at any stage, material can be considered to be decontaminated to the extent practical and acceptable for release as normal scrap.

A research program was set up to examine solvent decontamination of whole transformers and to answer three questions.

1. Is solvent decontamination feasible as a technique to satisfactorily clean PCB filled transformers?
2. When can PCB filled transformers be considered decontaminated and acceptable for release as normal scrap?
3. Does significant holdup of PCB's occur in parts of the transformer after decontamination and where is it held?

FIGURE 2
SOLVENT DECONTAMINATION
OF TRANSFORMERS

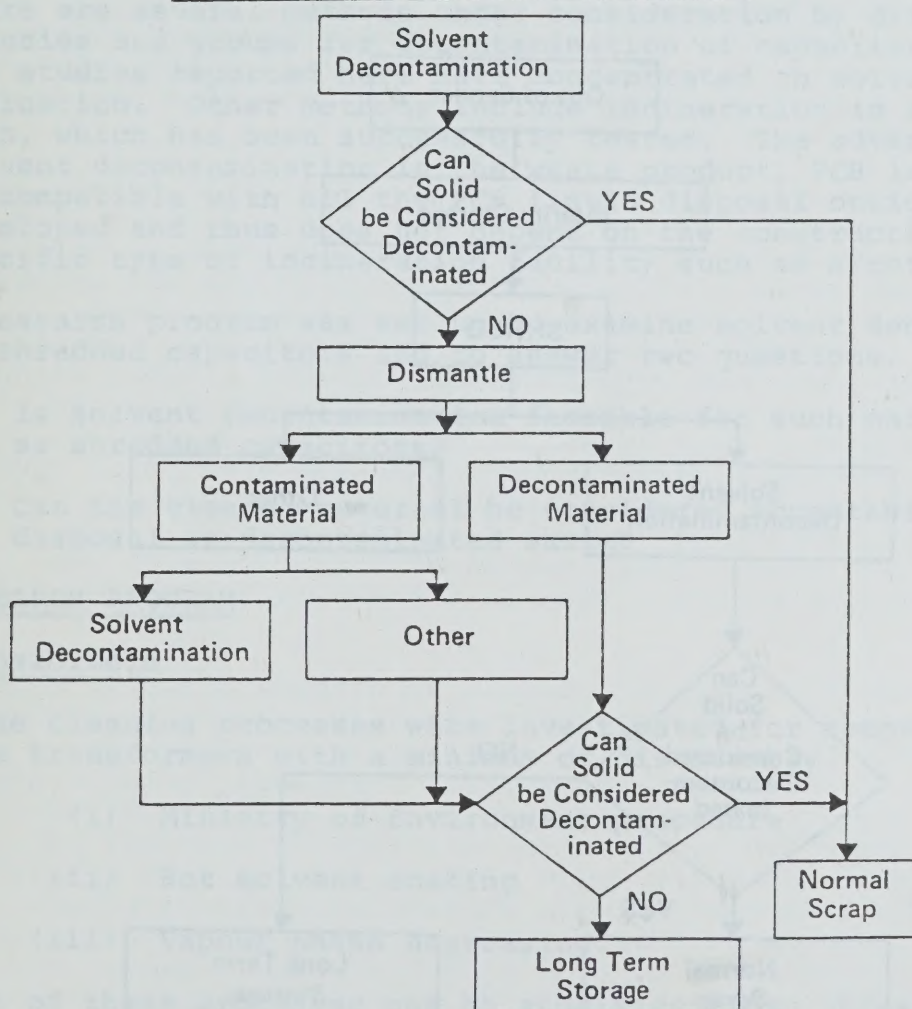
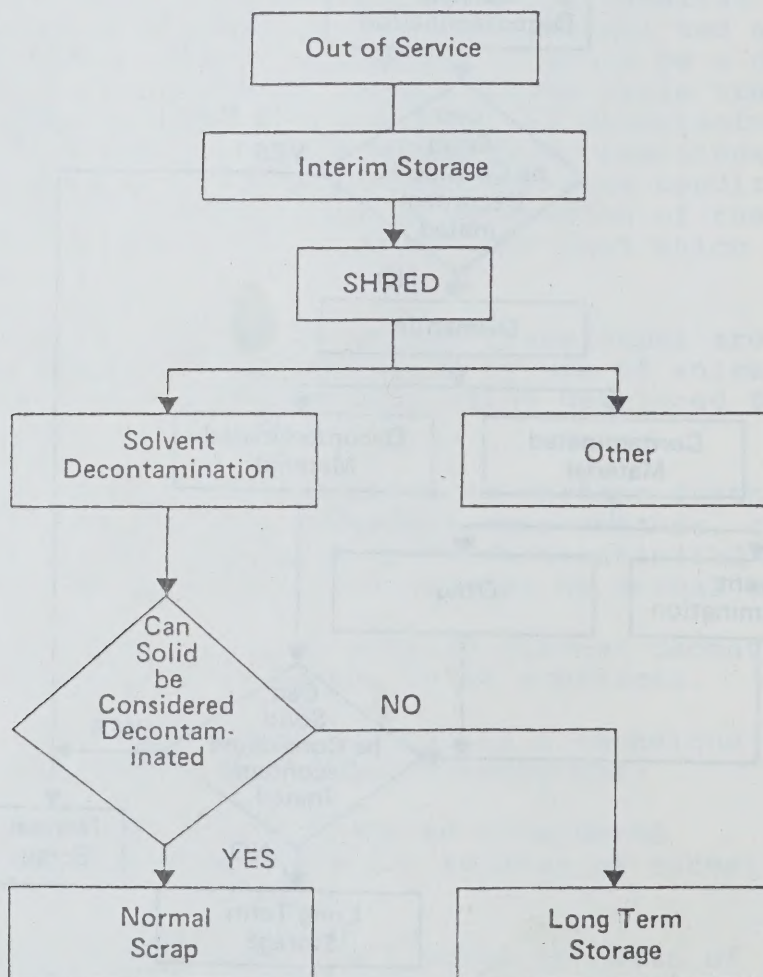


FIGURE 3
PCB FILLED CAPACITORS



Capacitors

Options for disposal of capacitors are outlined in Figure 3. Prior to any treatment of the capacitors they must be opened. One way to do this and achieve the objective of minimizing contact is by mechanical shredding. Tests carried out by both Ontario Hydro and a private company in the United States have indicated that shredding is practical for essentially all types and sizes of capacitors owned by Ontario Hydro.

The shredded material must be decontaminated in order that, as in the case of transformers, the decontaminated solid can be directed to normal scrap. This implies that solid material has been decontaminated to a level which can be considered as low as practical and acceptable for disposal as normal scrap.

There are several methods under consideration by different agencies and groups for decontamination of capacitor material. The studies reported here have concentrated on solvent decontamination. Other methods include incineration in a rotary kiln, which has been successfully tested. The advantage of solvent decontamination is the waste product, PCB laden solvent, is compatible with all the PCB liquid disposal options being developed and thus does not depend on the construction of a specific type of incineration facility such as a rotary kiln.

A research program was set up to examine solvent decontamination of shredded capacitors and to answer two questions.

1. Is solvent decontamination feasible for such material as shredded capacitors?
2. Can the cleaned material be considered acceptable for disposal as decontaminated waste?

RESEARCH PROGRAM

Transformers

Three cleaning processes were investigated for removal of PCB's from transformers with a minimum of disassembly:

- (i) Ministry of Environment procedure
- (ii) Hot solvent soaking
- (iii) Vapour phase degreasing

Each of these processes can be subdivided into three parts; draining, main cleaning procedure, supplementary cleaning procedure.

The Ministry of Environment procedure as outlined in Table 1 suggests that, after draining, transformers be cleaned by three successive soaks in an appropriate solvent. The duration of the draining period and the first soak was specified at 24 hours each but was not specified for the second and third soaks. In this study, the transformers were subjected to three 24 hour soaks followed by an extended soak for 36 days. Clean solvent was used for each of the three initial soaks but the third soak solution was returned to the unit for the long term soak.

In the main cleaning step of the hot solvent soak procedure the unit was filled with trichloroethylene at 50°C. The solvent was circulated through the transformer at a rate equivalent to two transformer volumes per hour for six hours while maintaining the temperature at 50°C. After cooling overnight with no circulation the solvent was again heated to 50°C and circulated for six hours as before. Heating and circulation were stopped and the unit allowed to stand for four days before the solvent was removed. In the supplementary cleaning step this procedure was repeated with clean trichloroethylene.

Vapour phase degreasing is a widely used industrial process for removal of oil, grease, wax, etc from metal parts, glass, and other objects. This is usually accomplished in an open tank and the articles to be cleaned are lowered into the hot solvent vapours. Vapour phase degreasing equipment has also been developed for cleaning the interior surfaces of large vessels such as storage tanks and railroad tankers. The solvent vapour is generated in a separate container and transferred to the contaminated vessel. This technique of external vapour generation was employed here. Vapour was generated until the entire transformer was filled with hot trichloroethylene vapours. Condensed solvent was continuously removed. Upon completion of the vapour phase degreasing step the unit was subjected to a supplementary soak in trichloroethylene for 6 days.

The exact quantity of askarel present in a transformer is not known; the nameplate gives nominal data only. Accurate information on the contents is required in order to estimate the efficiency of the treatment processes. Therefore, after cleaning, it is necessary to completely dismantle each of the test units to determine the location and quantity of retained PCB. The core and coil assemblies were removed and the case cleaned. The core and coil assemblies were dismantled yielding several thousand steel strips or plates and 3 to 5 tightly wound coils consisting of copper wire covered with insulation, paper, wood and cardboard. The steel strips were cleaned by immersion in solvent and representative samples of the major components of the coils were analyzed for PCB.

TABLE 1

MINISTRY OF ENVIRONMENT GUIDELINE FOR THE
DECONTAMINATION OF ELECTRICAL EQUIPMENT

1. THE TRANSFORMER SHOULD BE DRAINED BY OPENING THE DRAIN VALVE OR PUNCTURING THE UNIT AND ALLOWED TO DRAIN INTO AN APPROPRIATE CONTAINER FOR AT LEAST 24 HOURS.
2. THE DRAIN VALVE SHOULD THEN BE CLOSED OR THE UNIT SEALED AND FILLED WITH SOLVENT AND LEFT FILLED FOR AT LEAST 24 HOURS.
3. THE SOLVENT SHOULD THEN BE DRAINED AND THE TRANSFORMER RINSED TWO MORE TIMES BY FILLING AND DRAINING WITH CLEAN SOLVENT.
4. THE SECOND AND THIRD RINSES MAY BE RETAINED FOR USE AS THE FIRST RINSE IN DECONTAMINATING OTHER EQUIPMENT.
5. ALL RINSES SHOULD BE DISPOSED AS PCB LIQUIDS WHEN THE PCB CONTENT EXCEEDS 100 mg/kg (0.01 PER CENT).
6. THE DECONTAMINATED EQUIPMENT MAY BE DISPOSED IN ANY LANDFILL AUTHORIZED TO ACCEPT INDUSTRIAL SOLIDS OR BY SALE AS SCRAP METAL.

Results

The results obtained with each of the three cleaning processes have been summarized in Table 2. It should be noted that the minimum times specified in Table 2 for the cleaning steps in each process are somewhat less than actually employed, however, analysis of cleaning solutions at various times indicated that the minimum times stated are adequate.

Draining alone removed 91-96% of the PCB and the combination of draining and the main cleaning procedure removed greater than 99% in each case; MOE procedure 99.76%, hot solvent soaking 99.55%; vapour phase degreasing 99.10%. The addition of the supplementary cleaning procedure increased these figures to 99.95%, 99.96% and 99.72% respectively.

For disposal purposes the more critical figure is not the quantity of PCB removed but the quantity of PCB which remains when the cleaning process has been completed. Modification of the MOE procedure by extending the third soak for 16 days reduced the retained PCB to approximately 0.1 kg. The total solvent consumption was three times the transformer volume and the total elapsed time of the MOE procedure plus the 16 day soak was 19 days. Hot solvent soaking resulted in a similar retained quantity of 0.1 kg PCB with a total solvent consumption of twice the transformer volume and a total elapsed time of 4 days. Vapour phase degreasing accompanied by the additional six day soak required a solvent volume 1.2 times the transformer volume and a total elapsed time of 7 days and resulted in a residual PCB quantity of 0.7 kg. Following each cleaning process it was determined that retained PCB resided almost exclusively in the interstices between the steel core plates and in the paper and insulation of the copper coils.

Environment Canada guidelines for the management of waste materials containing polychlorinated biphenyls require the PCB content of a container, eg transformer, to be reduced as close as possible to a maximum allowable PCB content of 100 mg/kg. In Table 2 the ratio of the mass of retained PCB to the mass of the cleaned transformer, ie the PCB content, has been tabulated for each cleaning process after the main cleaning stage and the supplementary cleaning stage. It should be noted that the desired PCB/solid ratio of 100 mg/kg is approximated most closely by the hot solvent process. It is not possible to determine the residual PCB content of a cleaned transformer without completely dismantling the unit as was done here. As this cannot be done on a routine basis the requirement that the PCB content be reduced 'as close as possible to a maximum allowable PCB content of 100 mg/kg' is meaningless for cleaning whole transformers.

TABLE 2

COMPARISON OF TRANSFORMER DECONTAMINATION PROCEDURES

TRANSFORMER CLEANING PROCEDURES USING TRICHLOROETHYLENE	SOLVENT VOLUME REQUIRED	PCB REMOVED		PCB RETAINED AFTER EACH STAGE		CLEAN TRANSFORMER MASS kg	RATIO OF RETAINED PCB TO SOLID*mg/kg	PCB CONC IN FINAL SOAK mg/kg
MOE PROCEDURE DRAINING 24 h THREE 24 h SOAKS SUPPLEMENTARY SOAK, min 16 d	3X TRANSFORMER VOLUME	%	kg	%	kg	450	1022 222	3000
		91.18	170.25	8.82	16.46			
		99.76	186.25	0.24	0.46			
HOT CIRCULATING SOLVENT (50°C) DRAINING 3 h FIRST SOAK, min 2 d SUPPLEMENTARY SOAK, min 1 h	2X TRANSFORMER VOLUME	99.95	186.61	0.05	0.10	824	1432 133	1500
		95.65	251.80	4.35	11.44			
		99.55	262.06	0.45	1.18			
VAPOUR PHASE DEGREASING DRAINING 3 h VAPOUR PHASE, min 1 h SUPPLEMENTARY SOAK, min 6 d	1.2X TRANSFORMER VOLUME	99.96	263.13	0.04	0.11	824	2645 825	5000
		95.25	230.60	4.75	11.51			
		99.10	239.93	0.90	2.18			
		99.72	241.43	0.28	0.68			

Conversely, the studies undertaken by Ontario Hydro, have demonstrated that it is possible by solvent cleaning of whole transformers to consistently reduce the PCB content of the cleaned unit to a level considered acceptable for disposal as normal scrap.

Capacitors

Power factor correction capacitors which utilize PCB as the dielectric fluid consist of multiple layers of polypropylene film, paper and aluminum foil wound to form a hollow cylinder. The hollow cylinders are then pressed flat and a number of these sections tightly packed into the capacitor case; the number of sections and the size of each section depend upon capacitor design.

During manufacture the spaces within the capacitor are evacuated and askarel is impregnated into the interstices and the paper and plastic components of the capacitor at elevated temperature for a minimum of 48 hours.

A typical power factor capacitor contains approximately 15 kg of fluid and it has been estimated that from 10-50% of this is present as free liquid with the remainder impregnated into the capacitor core. In this program, out of service capacitors were drained, dismantled, and cut in the laboratory to simulate a shredded unit. The resulting solid was then subjected to various solvent cleaning treatments.

Results

The variables investigated were solvent type, solvent/solid ratio, degree of agitation, and particle size. It was determined that the majority of the PCB remaining within the pores and interstices of capacitor sections after draining can be removed by multi-stage cocurrent batch extraction using trichloroethylene as the extraction solvent.

The results are summarized in Table 3. Approximately 50% of the PCB present in the unit was removed by draining with the total quantity removed by draining and extraction being 99.9% in a relatively small number of extraction stages, leaving 0.01 kg of PCB per capacitor.

CONCLUSIONS

This work has demonstrated that PCB filled transformers can be satisfactorily decontaminated by a variety of solvent cleaning techniques. The procedure recommended by the Ministry of Environment proved to be effective in removing most of the PCB originally present however it was found that modification of the procedure reduced the quantity of PCB retained even further but extended the cleaning time per unit to almost three weeks.

TABLE 3
PCB REMOVAL FROM A POWER FACTOR
CORRECTION CAPACITOR BY DRAINING AND
MULTI-STAGE COCURRENT BATCH EXTRACTION

	PCB REMOVED	
	%	kg
DRAINING	50.20	5.2
TRICHLOROETHYLENE EXTRACTION	99.90	10.3
PCB REMAINING	0.10	0.01

Of the procedures tested the one that can best meet the objective of the cleaning program is hot solvent soaking using trichloroethylene at 50°C as described below.

- (i) Drain transformer for at least 3 hours or until no further liquid is removed.
- (ii) Fill the unit with trichloroethylene at 50°C and circulate at a rate equivalent to two transformer volumes per hour for 2 days while maintaining the temperature at 50°C.
- (iii) Drain, refill with clean trichloroethylene at 50°C and circulate as above for at least one hour before draining.

This cleaning procedure will produce a high level of decontamination, >99.9%, within 4 days using a solvent volume approximately twice that of the transformer. The solvent can be almost totally recovered by distillation and recycled and the volume of PCB liquid to be destroyed is not significantly greater than that which was present in the transformer.

It is expected that the laboratory results obtained in the capacitor cleaning trials could be duplicated on industrial equipment capable of handling Ontario Hydro askarel filled capacitors. Following shredding and draining the contaminated solid can be cleaned by multi-stage cocurrent batch extraction which involves complete cleaning of a single batch of solid before proceeding to the next. Given the relatively small volume of capacitor solids to be cleaned this appears to be the most suitable approach but it may be that multi-stage counter-current batch extraction, in which a number of solid batches are cleaned, simultaneously, is preferable. The data acquired here can be used as a basis for design of either system.

It is likely that a PCB solid waste handling facility, if constructed, will include equipment for solvent washing of transformers and possibly equipment for shredding and solvent extraction of capacitors at a single site. Trichloroethylene, the preferred extraction solvent, is nonflammable and can be separated from PCB's by distillation and recycled thus minimizing the volume of contaminated liquid produced in the cleaning process.

This experimental program has obtained many of the answers to the questions posed earlier and will provide a basis for discussion and decision making with respect to the safe disposal of PCB waste material generated by Ontario Hydro.

This program has also tested the procedures presently recommended by regulatory agencies and determined how successfully they meet the proposed guidelines for decontamination of PCB transformers and capacitors.

SITING HAZARDOUS WASTE DISPOSAL FACILITIES -
HOW TO PREVENT LAWSUITS and the "NOT IN MY
BACKYARD" SYNDROME

by DAVID ESTRIN

Note: Original version of this
paper was read on behalf
of Mr. Estrin at the
Conference by Councillor
Margaret Marland, City of
Mississauga.

(Revised Edition)

Preface

Both as General Counsel for the Canadian Environmental Law Association (1971-74) and in my private practice (restricted to environmental and energy law) I have often represented individuals and ratepayers groups who deem themselves negatively affected by governmental and private industry initiatives and who thus have opposed them.

On the other hand, as a hopefully aware citizen and as a professor in the Faculty of Environmental Studies, University of Waterloo, I know the safe disposal of hazardous wastes is something which must be implemented very soon, and not just talked about at conferences.

What I'm about to say is accordingly based on 10 years of experience working within the environmental regulatory system, working to a large extent with those experiencing - or as some might say the potential victims of - poor environmental planning.

I'd like to think that this experience has given me some insight as to how government and industry can both try and seek out public co-operation, as opposed to public opposition, in solving this serious problem.

I was therefore very pleased to be able to accept the invitation to speak to you today, because I believe that many in this audience are in a position - if you accept my analysis of the problem - to do something about the very real crises that exists in implementing a hazardous waste disposal strategy.

Almost exactly one year ago, on June 19, 1979, The Hon. Harry Parrott, Ontario's Minister of the Environment, through his Deputy Minister, delivered a speech to the 26th Ontario Industrial Waste Conference entitled "Liquid Industrial Wastes - Beyond the Seven-Point program".

Dr. Parrott commenced his remarks with the statement that:

The safe and efficient disposal of waste generated by western society's massive industrial structure is one of the major challenges in environmental protection today.

The Minister's remarks then went on to outline a strategy for handling liquid industrial wastes.

The Minister stated that:

The technical, administrative and economic aspects of waste disposal do not present insuperable difficulties. However we are faced with the major problem... of public attitude.

Just about any community you can name will object vigorously to any hint of a liquid industrial waste facility in their neighbourhood.

Why? Three reasons come to mind. Fear, mistrust and pure self-interest.

The Minister continued:

No one wants a liquid industrial waste facility, or for that matter any kind of landfill or disposal facility, near or in, his or her neighbourhood. There comes a time, however, when all but the most biased must accept that something must be done in the broader public interest and in accepting a degree of responsibility as a member of the community.

The Minister then stated the challenge that he saw was:

...to gain widespread public acceptance of the existence of disposal sites and the great need for new facilities. We ask Ontario residents to examine the technical facts and to make a judgement on the facts. We want Ontarians to know that our decisions will be based on these same technical facts.

Dr. Parrott has to be congratulated for bringing to the Ministry of the Environment a fresh attitude of "lets get something done about this grave problem". Unfortunately, the Ministry went about attempting to implement this initiative in a manner that ignored totally the very challenge that Dr. Parrott recognized in his speech of last year of "the need to gain widespread public acceptance of the existence of disposal facilities and the great need for new facilities".

The Ministry has utterly failed to gain widespread public acceptance of the need for hazardous waste disposal facilities; the fear and mistrust the Minister spoke of is continuously manifesting itself in large emotional public meetings across Ontario and in lawsuits brought, not just by individuals, but by municipalities, who are convinced, with their citizens, that the decision by someone in the Ministry of the Environment to locate a disposal facility in their municipality and in their neighbourhood is a formula for disaster.

Why do the Ministry of the Environment's proposals (or proposals by corporations or municipalities which have obtained an initial, prescreening approval from the Ministry of the Environment) stir up such violent emotions and opposition?

Obviously, for some persons with property located immediately near the proposed facility, there will always be the self-interest that the Minister spoke of. No matter how safe, some people will always object to an unusual installation in their area because they perceive their property value may be lowered. But this factor is not the main one that is behind these lengthy, protracted and emotional battles that have been and will continue to be fought in opposing hazardous waste facilities.

The factors that have led to such controversies and opposition and that will continue, unless appropriate strategies are invoked, are fear and mistrust. But this fear and mistrust have been directly the result of the Ministry of the Environment's inability to gain credibility as an agency with expertise, one which should be trusted by the public if it says something is needed and that something is safe.

If public leaders could trust in the credibility and technical competence of the Ministry of the Environment, and also could believe that the Ministry was willing to allow the public to participate in decisions about the type and siting of hazardous waste facilities, much of the fear and mistrust could be displaced. If public leaders could perceive that the Ministry was credible and trustworthy, the Ministry and citizen leaders could work together to convince the majority that there was no need to fear the establishment of a given facility, that the interests of the public had indeed been well addressed in the planning stages.

However the Ministry's key problems of public fear and mistrust, were unfortunately predictable based on another part of the Minister's

speech from 1979.

Having said, as quoted earlier, that "we need to gain widespread public acceptance of disposal sites and a great need for new facilities" and that "we ask Ontario residents to examine the technical facts and to make a judgement on the facts", the Minister went on to make one further statement (in the form of a rhetorical question) which is evidence of the MOE's real attitude and which has led to the utter failure of the Ministry's attempts to successfully do anything about siting hazardous waste disposal facilities in Ontario.

That sentence was:

Is it asking too much for citizens to accept a facility in their community because it's the best place for it and because the facility is required to serve the public need in general?

Although posed as a question, this was a statement of basic MOE philosophy: "we" (the Ministry of the Environment) know what's best and you (the public) will just have to accept a facility when and where we say it's required - because if we say so it must be safe in concept, design and in its siting.

Unfortunately, the Ministry's track record is such that quite correctly, the public has not accepted Ministry actions based on this - the real philosophy of "we know best".

Continuing fear and mistrust on the part of the public are justified in regard to the way the Ministry has gone about its proposals for the establishment of hazardous waste facilities because the Ministry

(and even Environment Canada) have publicly endorsed proposals that are not technically sound.

Let's look at some examples.

In 1977-78 public hearings were held by the Environmental Assessment Board, under the Environmental Protection Act, 1971, and under the Ontario Water Resources Act, in regard to a proposal for a waste disposal site which would include facilities designed to handle liquid waste treatment and the landfill of hazardous industrial wastes in the City of Nanticoke. The application was made by Nanticoke Waste Management Limited for a site consisting of approximately 100 acres. This was a proposal that had been scrutinized in advance by the Ministry of the Environment before the public hearings were held and obviously the Ministry's experts had judged the proposal to be technically sound at that stage. And at the hearings, the Ministry of the Environment presented evidence by some 12 witnesses, stressing the need for this facility and indicating that in the Ministry's technical assessment the effect on the environment would be minimal.

After 43 morning, afternoon and evening sessions and the filing of 163 exhibits the Environmental Assessment Board recommended against approval of the proposal. Primarily because of citizen intervention at the hearing, the following were demonstrated:

- (1) That the MOE accepted data and figures from the applicant without inquiring fully into their validity;
- (2) That despite its support for the use of plastic liners, the Ministry in fact had neither the experience nor expertise to properly evaluate them; and

- (3) That although normal MOE responsibilities include thorough investigation of proposals before recommending them for hearing, it was only during the hearings themselves that MOE admitted that if it had known about a local community water intake pipe it would not have recommended Nanticoke Creek as a discharge point.

The Ministry of the Environment had in this case not only encouraged the application to go forward, but as aforesaid had come and testified at the hearing in favour of it despite the fact that the evidence raised doubts in the minds of members of the Assessment Board that the effluent, even after dilution, "would meet the requirements of the Ministry of the Environment's water quality criteria for all of the critical parameters". The Ministry had come out to the hearing and were not so much concerned about "technical facts" as they were about the need for new facilities and that, to quote the observations of the Assessment Board "no other applications for facilities, similar to those being proposed were before the Ministry". It seems clear that in the case of Nanticoke, the Ministry's overriding desire to see some kind of facility established outweighed any objectivity as to the technical deficiencies of the project.

For in rejecting the Nantiocke proposal, the Board found:

- "the information provided at the Hearing was insufficient and tended to be contradictory, especially with regard to the soil permeability at the site, and location of the watertable";
- "the landfill proposal of the Applicant was based on a liner, the life of which was not predicted to extend for the full lifetime of the landfill. The resulting problem of how to handle the leachate, following the deterioration of the liner, was not addressed to the Board's full satisfaction".

One other interesting and important observation of the Board, of general application, was that:

In the consideration of the environmental effects of such a facility, the selection of the site is a significant factor. This requires the use of specialized techniques which are consistent with a concern regarding direct and potential environmental impact both on present and on future generations.

This important observation made in 1978, was apparently disregarded again by the Ministry of the Environment in the next example to be discussed.

The next example is the proposal by the Region of Durham to convert a redundant sewage treatment plant for the treatment of liquid industrial waste.

This proposal was supported in its conceptual stages both by the Ministry of the Environment and by the Federal Department of the Environment. The Federal Department of the Environment granted funds to Simcoe Engineering Limited to do a feasibility study on the conversion and at a later point in time the Ministry of the Environment entered into an agreement with Durham Region to pay for further engineering studies and to provide funding so that the Region (even though publicly funded on taxpayers dollars) should have sufficient "encouragement" to take the matter before the Environmental Assessment Board. Further, the Ministry promised in a written agreement to pay \$2,000,000.00 or more in regard to the cost of converting the plant if approved by the Environmental Assessment Board (again under the provisions of the Environmental Protection Act, 1971).

The Ministry's actions in entering into this agreement and statements made by Ministry officials certainly clearly indicated to the public that in the Ministry's view this was a technically sound proposal.

Yet the proposal as presented to the Environmental Assessment Board (in hearings which in terms of evidence have just concluded) was empty of detail:

- While the proposal submitted by Simcoe Engineering on behalf of the Region was bulky, approximately half of it consisted of newspaper clippings. When one looked to see the technical basis for the proposal, one found some considerable theoretical, first year university chemistry text book style discussion of the principles of neutralization and precipitation, but no serious attempt made to relate the theories to the actual facility. Very little was found in the proposal with regard to what processes would be carried on where and how;
 - In testimony before the Environmental Assessment Board the consulting engineer for the Region who was the project manager admitted he had not even counted accurately the number of existing tanks at the sewage treatment plant (existing tanks being a large justification in the mind of the proponent for going to this facility); the engineers assumed there were 22 tanks when in fact there were only 15; the confusion stemmed from not bothering to examine the existing facility carefully enough (a catwalk shown on diagrams of the existing facility across the middle of tanks leading to the mistaken assumption that certain large tanks were divided into two)!
 - No investigation was made by or on behalf of the Region in regard to soils around and under the site or of the hydrogeology of the site.
- In fact the plant is located on a floodplain and soils reports prepared when the sewage treatment plant was built

show serious potential for ground water contamination if leaks were to occur and that would in turn obviously lead to river contamination (the river being located within approximately 200 feet of the plant). This concern was heightened in that approximately one half of the existing tanks are 25 years old and all are buried or partially buried in the ground and the Region's consultants had no idea as to their condition or expected life.

In a report prepared by James F. MacLaren Limited for the Ministry of the Environment dated August 1979 (and published prior to the Simcoe proposal for the conversion of the Ajax sewage treatment plant) entitled "Development of Treatment and/or Disposal Site for Liquid Industrial Wastes and Hazardous Wastes", MacLaren's stated (p. 4-1) that there tends to be a strong public mistrust of the contention by the technical community that methodology of site selection is adequate for safe and effective siting, and MacLaren's went on to suggest that, historically, the public's confidence must be satisfied in three potential areas of genuine concern, including "that the transportation of hazardous wastes into the adjacent environment cannot occur". It was obviously the case that in making the application to the Environmental Assessment Board the Region of Durham and its consultants and indeed the Ministry of the Environment in its in-house evaluation of the proposal had not even bothered to address in any serious manner, if at all, this rather critical factor and nevertheless let the proposal go to the Environmental Assessment Board without such a key factor having been addressed.

Further, MacLarens had also indicated that on the basis of past failures by private enterprise to establish waste disposal facilities, that public concerns had to be satisfied by providing adequate evidence of the need and reliability of the proposal. In order to satisfy at least the majority of the public's concerns, MacLarens stated the following specific elements must be addressed:

- (a) The public must be made aware of the consequences involved both in accepting or rejecting a site;
- (b) Siting criteria must be established so as to clearly identify the risks involved;
- (c) The public must have reasonable confidence in the technology proposed;
- (d) The public must have confidence in the criteria selection process;
- (e) The siting process must be developed to involve the public during the early planning stages.

Again, when one reviews the Ajax proposal, one quickly finds that several of these basic elements that need to be addressed in order to achieve public confidence, as suggested by MacLarens, were not addressed at all in the proposal. Ignoring both the EAB's recommendation in the Nanticoke decision, and item (b) by MacLarens regarding the need for siting criteria, there were no siting criteria established in order to select an appropriate site.*
(In so far as such siting

criteria were developed by MacLarens in the MacLaren Report the Ajax site fails to meet almost every critical aspect of these.) And obviously the public in the case of Ajax was not involved at all in the siting process "during the early planning stages". The Region's major scheme to involve the public in the case of Ajax was to establish an office in the community, approximately one month prior to the scheduled hearing by the Environmental Assessment Board, giving the public press releases and other predigested materials on why the facility was needed.

*Except, of course, that they were attempting to locate a redundant sewage treatment plant in Durham Region. - 81 -

The Ministry in underwriting and advocating the Durham proposal, obviously also ignored its own "Guidelines for Environmental Protection Measures at Chemical Storage Facilities" published by the Waste Management Branch in October, 1978. Under the heading "General Principles of Engineering Controls" it is stated:

Changes in the chemicals to be stored in a given facility should not be permitted until a competent assessment has been made of the suitability of the facility for such a change in service.

There was no assessment made, in the case of the Ajax proposal, of the existing state of the Ajax facility in terms of the existing character of the pipes and tanks and the degree to which these would be rendered unsuitable or hazardous as a result of new chemicals introduced into them.

The same principles of engineering controls continues:

Where possible, storage facilities should not be located where, in the event of a spill, waste product may enter a natural water course or sewerage or drainage system or contaminate potable surface or ground water supplies
....

It was obvious that this basic principle was ignored by the MOE when it agreed to support the Durham proposal.

The third example leading to public fear and distrust of Ministry advocacy of the establishment of a given hazardous waste disposal facility stems from the proposal to dispose of PCBs by burning in the St. Lawrence Cement kiln in Mississauga. This proposal was supported both by the Federal Department of the Environment and the Ministry of the Environment who were initially responsible for developing the concept on

a technical basis.

Initially both governments were responsible for creating fear and mistrust by carrying on this activity in secret and without allowing their experimental conclusions to be subjected to public scrutiny. Both governments went so far as to plan to use St. Lawrence Cement as a PCB disposal facility without informing the public, let alone calling any public enquiry to allow the scientific conclusions to be subjected to public scrutiny, even though this would be the first time anywhere in the world where a cement manufacturing plant would be used as a PCB waste disposal facility.

The internal decisions by the Ministry of the Environment and the Federal Department of the Environment to go ahead with the use of St. Lawrence Cement as a PCB destruction facility quite reasonably led to public fear and mistrust when such a decision was made in the absence of any criteria having been established for what is a safe and desirable location for such activity to occur.

When the Ministry, sometime later, asked M.M. Dillon Limited to develop criteria for the establishment of an interim PCB storage facility, M.M. Dillon, in a lengthy report, suggested that if fire occurred in a storage tank containing 20,000 gallons of liquids with 10% PCB content*, the toxicity of materials being burned would be such as to require that all persons within 10 kilometers downwind of the tank within a sector of width approximately 2,000 meters wide would have to be evacuated. In practice the time of dispersion of the cloud would not allow sufficient time for evacuation to be carried out before the population was exposed

*which is exactly the blend and volume to be used for the proposed test burn

to essentially the total dose of PCBs. Therefore in selecting a site for storage of PCBs based on the possibility of a fire M.M. Dillon recommended a criteria that such sites not be considered where major population centres occur within a 10 kilometer radius of the site. In fact there are approximately 129,000 persons residing within 10 kilometers of the St. Lawrence Cement plant (within the City of Mississauga) and approximately 50,000 residing in the Town of Oakville within 10 kilometers of St. Lawrence Cement. This means that approximately 75% of the residents of the City of Mississauga and approximately 70% of the Town of Oakville could need to be immediately evacuated from their homes if a fire were to take place at the St. Lawrence Cement plant when the material needed for a proposed test burn were to catch fire.

The Dillon criteria also recommended that:

- (a) PCBs should not be stored within one kilometer of a food processing plant on the basis that PCBs escaping in a fire would contaminate such food. Yet there is such a plant located virtually immediately north of St. Lawrence Cement;
- (b) There should be no storage within one kilometer of a large lake which could be used as a potable water supply. In fact Lake Ontario is within one kilometer of St. Lawrence Cement and in fact there are two water treatment plants serving the City drawing water from Lake Ontario in close proximity to St. Lawrence Cement;
- (c) Such a storage site should not be located in an area of environmental hazard, for example, in a floodplain or where there is a permanent water course directly through the site. In fact there is a water course running directly through the St. Lawrence Cement site, which the Ministry of the Environment was unaware of previous to this

information being given to it by the City during the course of a Court case between the City and the Ministry. And in a preliminary study prepared by consulting engineers for the Credit Valley Conservation Authority there is indication that widespread flooding could occur all around the St. Lawrence Cement plant in a one in twenty-five year storm. Again, the MOE had been unaware of this;

- (d) Dillon also put forward criteria that would prevent a storage site being chosen if the soil conditions were such as to indicate that PCBs if spilled or leaked on the ground would quickly percolate through the soil. In fact the Tricil Company property immediately to the east of St. Lawrence Cement was considered by the Ministry consultants as a PCB storage site and for reasons that the Tricil site was sandy and therefore "not suited to contain spills" the Tricil site was rejected on that basis. Yet the Ministry made no studies of the soil under St. Lawrence Cement neither before doing the initial test burns or to date. Given the proximity of the Tricil plant to the present location intended for storage of PCBs it would be prudent, in the absence of a specific soil study, to conclude that there is a probable risk of sand being located under St. Lawrence Cement and that accordingly it also is not a suitable location technically for the storage of PCBs. Yet no such study has yet been done; and there have been spills of PCBs onto the ground at St. Lawrence Cement when previous PCB burning and storage took place at that plant. These spills sufficiently contaminated the soils as to necessitate removal and replacement of such soils;

Other facts which emerged only after Mississauga learned of and objected to the planned burning include:

- (e) That in the only air sampling that has taken place in the Mississauga area when PCBs of the concentrations to be stored and burned during the test burn (or later burned if approved as a permanent waste disposal facility) extremely high readings of PCBs in air were measured close

to the plant boundaries. These are well beyond the Ministry of the Environment's guidelines for safe levels of PCBs in the air. These high readings were attributed to handling and storage of PCBs (as opposed to emissions as a result of burning);

- (f) For many years St. Lawrence Cement has been illegally polluting in terms of dust and particulate matter from its cement manufacturing activities. The Ministry had to order St. Lawrence Cement to clean up its emissions and as of January, 1980, there appeared to be matters yet uncompleted. Burning of PCB wastes, according to Federal Department of the Environment studies, would significantly increase the amount of dust produced in the cement manufacturing process;
- (g) Obviously, neither the Ministry nor St. Lawrence Cement had conducted an environmental or social impact study in regard to these or other public hazards, environmental, planning and social considerations and conflicts that would be associated with storing PCBs at St. Lawrence Cement prior to the previous test burns being conducted. Further, no such studies were conducted prior to the Ministry advocating the disposal of all Ontario PCBs at St. Lawrence Cement.

With that list in mind one can hardly wonder as to the reasons that motivated the City of Mississauga to pass By-laws that would restrict the burning of PCBs in that City. Certainly there were reasonable grounds for the City to have fear and mistrust in the technical and social judgements (to the extent these were made at all) of the Ministry of the Environment in advocating the burning of PCBs given these many considerations.

Indeed what emerges from all of the three examples is a clear pattern justifying the Ontario public's refusal to accept the Ministry's proposition that the technology of hazardous waste destruction and the site selections made or endorsed by the Ministry of the Environment are adequate and safe.

The Ministry, while taking commendable initiatives in promoting technological initiatives has, in its haste to see such initiatives undertaken, failed to rigorously examine such proposals to ensure that they are not just expedient but are technically sound and that they are based on reasonable criteria such that the location proposed would be as safe as can reasonably be attained.

The Ministry of the Environment and the Federal Department of the Environment (to the extent the Federal Department of the Environment has allowed itself to be seen to be endorsing proposals supported by the Ministry) have lost the key factor which is fundamental to the public becoming positively involved in a process that may lead to the acceptable siting of a hazardous waste facility. That factor is the credibility of the sponsoring agency. The Ministry is perceived, and rightfully given such examples, as willing to endorse facilities without the proper internal scrutiny. Further, and even worse for MOE credibility and trustworthiness, is the fact that while a "public hearing" will be held to allow the public to ask questions, the hearing process is completely one-sided. Given such a one-sided process the public again is entirely skeptical that their concerns can ever be adequately addressed. The one-sidedness stems from the following:

- (a) The proposal that comes before a hearing of the Environmental Assessment Board does so only after having been initially scrutinized (or supposedly scrutinized) by the Ministry. This indicates to the public that the Ministry has already internally approved a given proposal when the hearing is called;
- (b) The proponent can expect, under the policy of the present Minister, that its hearing costs, with regard to preparation of engineering and technical witnesses and legal fees, will be underwritten by the Ministry of the Environment;
- (c) The proponent can expect that the Ministry will have its experts attend at the hearing to testify in favour of the proposal;
- (d) The public, on the other hand, can expect no money to consult experts or retain legal advice.

Hearings over hazardous waste disposal facilities have lasted 50 to 80 days, they generate hundreds of exhibits, thousands of pages of transcripts and proponents can easily spend \$200,000.00 - \$1,000,000.00 in preparing for and presenting their case. Given these conditions, such hearings are truly a modern version of Lions vs. Christians.

(The fact that the Environmental Assessment Board can on its own call witnesses or call ones requested by citizens is no answer to this problem. No party would call as a witness someone who has not had an opportunity to review the technical proposal, who has not examined the site and who has not had an opportunity to discuss their views in advance of testifying, with the party for whom they would testify. Only if the Environmental Assessment Board would pay such preparation costs even if the expert never testified would the EAB's ability to call such witnesses be useful to citizens.)

Basically, the Ministry of the Environment suffers from severe schizophrenia. On the one hand it wishes the public to believe that it, as an expert agency, knows what is best and that therefore the public should accept the fact that when it says technological fixes are appropriate in a given location that they indeed are. Yet on the other hand the Ministry has been on repeated occasions, as the examples discussed above indicate, a wholly partisan advocate of woefully inadequate technological fixes.

Perhaps the Ministry should really "come clean". Perhaps it is time for the Ministry to frankly admit that its real philosophy is that contained in the "we know best" approach indicated by the Minister in last year's address. If it admitted that it was a partisan advocate it could stop pretending that it wished to have public acceptance of such facilities. The Ministry could then simply impose by law such facilities without hearings and remove through further Legislation any public right to sue or prevent such facilities from being sited or operated. Facilities could then be

established quickly and wherever and whenever needed according to the views of the Ministry. This would at least be an honest approach.

However if this alternative is politically unacceptable (and I do hope it is) then this means the Ministry's approach to the whole question of the establishment of hazardous waste facilities must be fundamentally altered.

It must be altered in a way which returns credibility to the Ministry of the Environment so the public will participate and assist in a program designed to solve the problems of hazardous waste disposal.

Can this be done?

In the summer of 1979 I had the fortunate experience of participating in a three-day workshop in Michigan sponsored in part by the American Environmental Protection Agency with regard to involving the public under a U.S. Federal Resource Conservation & Recovery Act Program. The seminar brought together, at agency expense, leaders of public interest groups, environmental groups, citizens who had been involved in fighting waste disposal sites, politicians and government administrators to discuss the problems of hazardous waste management.

What emerged after the three-day program was a consensus wherein these community leaders were going to leave the conference willing to convince their memberships that the problem of hazardous waste had to be addressed and no longer could these groups or any citizen afford to articulate the "not in my backyard" syndrome.

How was this remarkable attitudinal position reached?

I believe it was reached through convincing the citizen representatives that there were sound technical solutions to the waste disposal problems in many cases, but more than this, that citizens were acknowledged to have a fundamental role in promoting the development of such facilities on certain terms.

How can such citizen co-operation be achieved in Ontario?

How can we avoid lawsuits and effectively deal with the "not in my backyard" syndrome? Let me put forward my own Seven Point Program:

1. In order to attempt a consensus for the acceptance of a waste facility it is important not to impose, in the first place, a decision that there must be a facility located at a certain spot. Rather one must try to put forward a program whereby leaders of the community (not just those elected persons but citizen group leaders, ratepayers etc. and environmental groups in particular) are brought together in order to ascertain, as a result of unbiased information, that there is a problem to be solved and also to indicate that those persons will be given a full opportunity to participate in the solution. It is my considered belief that if an environmentally conscious leadership in any given community ascertains that there is a problem I believe they will be the first ones to try and assist in coming up with a solution. However, the Province or the initiating agency or private industry must not publicly suggest that a given facility is needed in a given location. Rather the approach would be for the government to indicate that as a result of studies it would seem that certain facilities are needed in certain general areas and then invite the citizens in these general areas to participate in a program to determine where in that area or region

particular facilities might be located, if such facilities are technically sound. As part of this stage, there should be public hearings on the technical processes - unlinked to specific locations, and monies given to enable scrutiny of such processes to citizens who would participate in such hearings.

2. The public in a given locality must be made aware that their general area is not being singled out. Information about the extent of generation in given areas must be made available and no one area made to feel that it is likely to become the dumping ground for all of Ontario hazardous waste or indeed a major portion of it. The Ministry must have a Province-wide plan for hazardous waste siting and many areas should share the burden. Public opposition rises when citizens do not perceive the proposal as solving a problem caused by their area. They feel no need to solve a problem they did not create. A Province-wide plan would overcome some of this type of reaction.
3. At the same time that these initiatives are taking place the government must be willing to take initiatives to cause citizens to understand that the government will not stand idly by but will take concrete measures to ensure that wastes will not continue to be generated in future as they have been in the past and that new industries which generate liquid or hazardous wastes must develop means of disposing of these wastes on-site or on a co-operative basis. Similarly the government might indicate that it is going to make the generator of wastes legally co-responsible with the disposer for many off-site impacts, so that responsibility becomes clearer in law. (Much has already been achieved in Ontario in this area under the so-called "Spills Bill" Amendment to the Environmental Protection Act enacted in 1980.

4. The concept must be fostered as basic to waste management strategy that the government neither wins nor loses if it does not achieve the construction of a given facility in a given area, as there may be sound technical or social reasons why a given area is not a proper place. Indeed the Ministry of the Environment must become disassociated with the advocacy of a particular facility at a particular location. If the public can perceive that the Ministry is not about to ram a specific facility down their throats in a specific location but rather that there are options open and that the Environmental Assessment Board is free to listen to facts and arguments as to whether or not a given site is really a safe site and that given technology is safe or not then I believe the Ministry will be in a much more credible position to achieve the implementation of an industrial waste management program. Adoption of this concept - that the government neither wins nor loses if it does not achieve the construction of a given facility at a given location - must be the first order of business if the Ministry is going to achieve public credibility.

5. Funding must be made available to at least a coalition representing all those who would participate in hearings into the establishment of a given facility in each of the proposed locations where such a facility would be located. The cost of providing funds to groups is not that great. \$15,000 to \$25,000 would not be a substantial amount in contrast to the amount spent by proponents and paid for by the Provincial Government. Certainly this level of funding would represent a marked improvement on the present situation of citizens groups; it would allow them to consult experts independent of the government and of the proponent and to enable them to perhaps even come to the realization that the technical aspects of the matter are not really as grave as they first feared. In

any event the monies could be used to allow the citizens to help present their case. The monies given to the group in this process could later be recovered in part or in total by fees to be charged industries who use such sites.

6. Compensation must be a possibility for property owners in the vicinity of a facility who can demonstrate some depreciation of property value or other interference with their life style that will be associated with the use of the facility regardless of any direct pollution.
7. The Ministry must use personnel to represent it who are sensitive to the public's needs and concerns and who can demonstrate that the Ministry wishes to involve the public in the decision-making process at a stage when such input can be useful. The past "public participation programs" consisting of displays and having technical representatives of the proponent answer questions a month before a hearing starts (as happened both for Mississauga and Ajax) is hardly a public participation program - it's more like a public indoctrination program.

Lawyers and other officials appearing for the Ministry must be less advocates for the proponent and more concerned about and advocates for the public interest, recognizing that a particular application may indeed have defects or even arguing against a facility in a particular location.

Conclusion

Only if the public feels it can trust the technical information and credibility of the Ministry of the Environment and that the Ministry truly wishes the public to participate in a meaningful way will we be able to stop lawsuits and reverse to a large extent the "not in my backyard" syndrome.

Past mistakes and past hard-line utterances made by spokespersons on both sides of this issue must be put aside as the problem to be solved is just so great as to not allow the Ministry, the Minister, or indeed any spokesman for the "public interest" to think that any one of them has the "full truth". A co-operative attitude must be struck. I hope those ideas I have indicated in this address will form some foundation for that co-operation to be achieved as between the public and the government.

THE POLITICAL REALITIES OF ENVIRONMENTAL DECISION-
MAKING IN THE 80'S

by
The Honourable Harry C. Parrott, D.D.S.
Ontario Minister of the Environment

Two major and pressing priorities in the 1980's involve the phenomenon commonly called acid rain and the disposal of liquid industrial waste. Both are, by their very nature, highly politicized.

Acid rain is a global problem. In Ontario, watercourses are being polluted mainly from sources beyond Ontario's control -- mainly in the northeastern United States.

Ontario's policy is to press Canadian federal authorities to negotiate an effective international abatement agreement with the United States. At the same time, this Province fully accepts its own responsibility to minimize contributions to acid rain emanating from Ontario sources.

The Ministry of the Environment is under almost constant attack from environmental groups, Opposition members of the Legislature, and certain elements of the news media. Thus, progress is impaired by an adversarial atmosphere.

Similarly, immense problems in the control of liquid industrial waste are being confronted amid a growing chorus of emotion-charged criticism.

Ontario's policy is that every proposal for disposing of such waste be subject to full and free public discussion. This is necessary, but it tends to delay solutions to urgent problems.

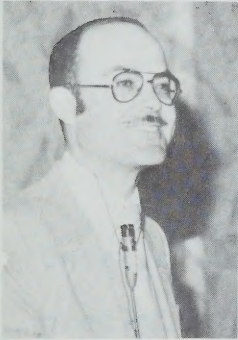
Note: Dr. Parrott spoke from notes and did not have a formal text that could be incorporated in these Proceedings.

SESSION III
CHAIRMAN



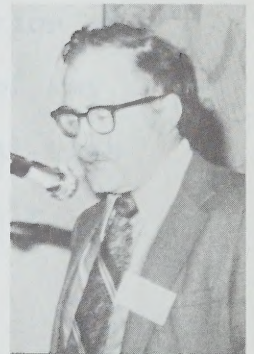
Grant Mills

Director
West Central Region
Environment Ontario, Stoney Creek



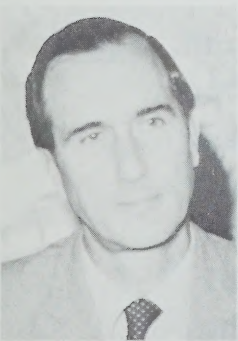
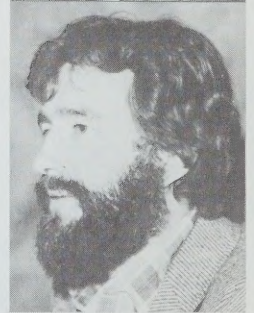
An Introduction to the Topic of Acid Rain

E. Piche, Co-ordinator for the Acidic
Precipitation in Ontario Study and the
Sudbury Environmental Study
Environment Ontario, Toronto



**Acid Precipitation – Some Social-
Economic Considerations**

Dr. J. A. Donnan and Dr. L. T. Foster
Senior Economists
Program Planning and Evaluation Branch
Environment Ontario, Toronto

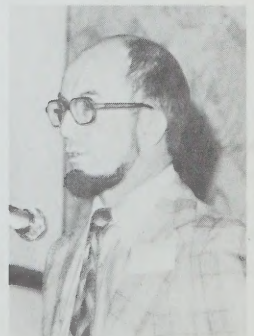


**Decreasing Sulphur Dioxide Emissions
from INCO Metals Company's Copper
Cliff Smelter**

J. Stuart Warner, Vice President,
Occupational Health and Environment
Inco Limited, Toronto

**Davy-Saarberg Hoelter Flue Gas
Desulphurization System**

Allan Pollock
Senior Process Engineer
Fertilizer and Sulfuric Acid
Acres, Davy, McKee Ltd.
Rexdale, Ontario



AN INTRODUCTION TO THE TOPIC OF ACID RAIN

by
E. Piche

Co-ordinator for the Acidic
Precipitation in Ontario Study
& Sudbury Environmental Study,
Ontario Ministry of the Environment

This presentation will outline the evolution of the Ontario Government's concern with the acidification of precipitation phenomenon with specific mention of key turning points from both scientific and political view points. In addition the comprehensive and totally integrated Ontario program will be reviewed.

Note: Mr. Piche spoke to a slide presentation from notes and personal experience. The bulk of his presentation is contained in a new publication "The Case Against the Rain" which is soon to be released by Environment Ontario. There was no formal text of this paper to be included in these Proceedings.

THE ECONOMIC IMPLICATIONS OF
ACID PRECIPITATION

by

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THE ECONOMIC IMPLICATIONS OF ACID PRECIPITATION

1. INTRODUCTION - A DILEMMA

Acid precipitation presents society with a dilemma. On the one hand, "acid rain" is acknowledged by the Canadian Federal Government as "one of the most serious environmental problems facing us today" (Environment Canada, 1980). The United States government has expressed similar sentiments (USEPA, 1979). According to another author, "acid rain is so deadly that many observers have dubbed it the environmental crisis of the decade" (Weller, 1980). Some authorities warn that if government and pollution sources do not initiate massive abatement and rehabilitation programs soon, the ultimate destruction of aquatic life in lakes and streams and the adverse effects on terrestrial ecosystems could be both extensive and irreversible (United States-Canada Research Consultation Group, Oct. 1979).

On the other hand, sulphur dioxide (SO_2) and nitrogen oxides (NO_x) abatement programs will likely impose substantial cost burdens on governments, the electric power industry, and on firms in the private sector which are the sources of these pollutants. For example, the United States Council on Environmental Quality estimates that power utilities alone will have to spend more than \$11 billion per year by 1987 to achieve U.S. federal emission standards (U. S. Council on Environmental Quality, 1979, p. 666). Here in Canada, careful estimates of the costs of SO_2 containment by the electric power industry have not been published although abatement programs for the Inco facility in Sudbury are expected to

cost upwards of \$400 million in capital expenditure (Environment Canada, May 1980).

The issue is a dilemma because the substantial amounts of public and private resources that will be required to investigate and resolve acid precipitation problems will have to be taken from some other purposes. Provincial and federal governments will have less money and man-power to devote to other environmental problems unless taxes are raised to pay for these and other worthy social programs. Investment funds that will have to be spent by firms in the private sector for air pollution abatement will have to be taken from other uses that are perceived by the firms and their owners to be more profitable.

All of this means that, in the present period of economic recession, both government and business are being asked to do more with less. Choices must therefore be made about how much money and man-power ought to be devoted to acid precipitation as well as to other worthy environmental and social problems. This is clearly an economic problem and the application of economic principles can help to determine a socially desirable level of expenditure and effort to be directed at acid precipitation and other environmental problems. Furthermore, an understanding of the economic dimensions of the acid precipitation problem is essential to the development of policies and programs that will resolve these concerns in an effective, efficient and equitable manner.

Consequently, the primary objectives of this paper are:

- (a) to define the economic implications and consequences of acid precipitation, its effects and efforts to curtail it.

- (b) to indicate what is presently known about these implications and consequences in a theoretical and a practical sense.
- (c) to describe how we intend to expand our understanding and knowledge of these questions.

In the course of accomplishing these objectives, we shall distinguish between some of the real and the imagined economic consequences of pollution control costs and regulation. Finally, we offer some comments and suggestions concerning policies which we believe will help to initiate more effective and timely emission controls and, at the same time, provide funding for needed rehabilitation programs.

2. THE SOCIO-ECONOMIC DIMENSIONS OF ACID PRECIPITATION

Acid precipitation is a result of the following sequence of circumstances:

- (a) Sulphur dioxide (SO_2) and nitrogen oxides (NO_x), which are the waste products of fossil fuel combustion and the smelting of certain base metal ores, are discharged into the atmosphere. (1)
- (b) These contaminants are transported hundreds of kilometers by weather systems.
- (c) Pollutants undergo photochemical conversion to acidic compounds in the atmosphere during long range transport.
- (d) Acidic compounds are deposited as constituents of rain and/or snow and as dry particulate matter.

The rate at which these acid compounds are being deposited with snow, rain storms or dry fallout has been associated with the following environmental and ecological effects:

- (a) Acidification of lakes and streams with low buffering or neutralization capacities.
- (b) Increased levels of dissolved heavy metals in these acidified waters.
- (c) The disappearance of fish populations from affected waters due to direct toxicity, increased stresses, interference with reproduction or destruction of aquatic vegetation.
- (d) Decreased visibility associated with increased sulphate levels derived from SO_2 emissions.

The following environmental and ecological effects are not well documented but are of concern:

- (a) Damages to forests and agricultural systems.
- (b) Increased risks to human health through the ingestion of dissolved heavy metals.
- (c) Increased risks to human health from the airborne contaminants (eg. sulphates, oxides of nitrogen, etc.) which are associated with acid precipitation.
- (d) Corrosion of structures and property.

A major question concerning acid precipitation which faces

environmental agencies across North America is the determination of socially desirable levels of SO_2 and NO_x emission controls and ecosystem rehabilitation efforts to resolve acid precipitation problems. There is, of course, no single answer to this question. The resolution of these problems will involve a long process of making decisions under conditions of uncertainty, the integration and evaluation of massive amounts of divergent information and the movement toward objectives in a series of iterative starts and stops rather than a smooth jump to the ultimate goal. Economic principles are particularly helpful in providing an integrative framework and in organizing one's thinking under these circumstances. In the following paragraphs, several ways of setting objectives relevant to this issue will be cited and critiqued. The use of economic principles in setting of these objectives will then be described.

Ambient air quality objectives (ie. the concentration of contaminants in the air at "point of impingement") are established by environmental agencies at levels which current knowledge and information indicates to have no discernable adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and human well-being (Environment Canada, January 1980). Allowable emissions are calculated to achieve these ambient air quality objectives under specific weather and location conditions. Dispersion rather than containment or removal has been the dominant air pollution control method since it generally was the least-cost means of achieving the objectives. Moreover, ambient air quality problems were mainly confined to the vicinity of the pollution sources. The concentrations of most air pollutants are well below the objectives in rural areas.

Under this air quality management approach, total loadings of pollutants to the atmosphere are not a relevant problem. It now appears that reductions in acid deposition will require emission reductions greater than that required to comply with ambient air quality objectives. A great deal of research is currently underway to better understand atmospheric transport and chemical conversion processes, acidic deposition rates and the environmental and physical damages caused by acid precipitation. It is hoped that these investigations will indicate how much emissions should be reduced in order to curtail acid deposition enough to stop the adverse environmental effects. If these "thresholds" can be determined, then one need only set emission standards and require all sources to meet them. However, the determination of these thresholds is proving to be an extremely time-consuming and information intensive task. Most importantly, this approach ignores the costs of achieving the objectives and does not facilitate the identification and evaluation of any environmental-economic trade-offs that might be necessary.

Similarly, studies are being initiated to determine the consequences and the appropriate methods of lake neutralization with lime. There are also other "defensive" and rehabilitative actions that could be employed whether or not abatement efforts are undertaken. However, each of these methods can be implemented to varying degrees of effort and costs. The determination of physical thresholds, while a necessary task, does not provide a decision criterion.

Another approach for setting emission objectives is to base them on the costs of control. Abatement costs for different levels of control can be determined, and the emission objectives set on the basis of what the sources

can be expected to afford or be willing to invest in abatement programs. Even if one could judge what a polluter could afford, this criterion for setting abatement or emission objectives does not ensure that the damages caused by the pollutants will be sufficiently reduced.

Finally, there may be those who advocate total elimination of pollution and acid deposition at any cost. This policy is technically feasible in that all polluting sources could be shut down. However, the social and economic costs of this objective would likely be untenable.

All of these criteria or bases for setting objectives for emissions or levels of effort are deficient in that they do not consider explicitly all of the relevant economic dimensions including the adverse (and beneficial) effects of pollutants, the costs of their control or of rehabilitation efforts and the preferences of people and the groups who make up society. Economic principles provide analytical tools to explicitly consider each of these important features as well as a decision criterion with which to choose defensible objectives.

The tool is benefit-cost analysis and the criterion is economic efficiency. An objective of the efficiency criterion is to ensure that all of society's resources, public and private, are utilized productively and that costs to the public, to firms and to individuals are minimized.

Using the efficiency criterion, the appropriate level of pollution abatement and rehabilitation effort is the level at which the extra social and private benefits of pollution controls and/or rehabilitation activities are equal to or greater than the extra costs of these programs. Consequently, in order to find the most economically efficient level of pollution abatement and environmental protection effort from society's point of view, the magnitude of the benefits associated with varying degrees of emission reductions and rehabilitation efforts must be determined and compared with the costs of these endeavours.

Consequently, three additional economic dimensions of acid precipitation must be identified and enumerated. The first is the value people place on the various effects and damages caused by the pollution phenomenon. The adverse effects and damages that are reduced or avoided by the implementation of abatement or remedial measures constitute the benefits of such efforts. One important characteristic of environmental damages and of the benefits of pollution control are that they have attributes of Public Goods (2). This means that people cannot easily be excluded from the effects of pollution or the benefits of its control. Consequently, parties that cause external pollution effects take little or no notice of them in making decisions since they are not penalized for causing them or remunerated for curtailing them. Thus too much pollution is generated and too little pollution control is achieved without government

intervention.

A second characteristic of environmental pollution is that it impinges upon resources and activities that are not generally bought and sold in markets. These would include sport fishing and other recreational pursuits as well as visibility and other aesthetic qualities. Consequently, there are no market prices associated with these effects with which to estimate their relative value and market significance. The methods and problems of estimating the benefits of SO₂ abatement and ecosystem rehabilitation programs will be addressed in the subsequent Section.

A second important economic dimension concerns the costs that must be incurred to achieve emission controls and ecosystem rehabilitation. The costs of these efforts are the value of the benefits that could be realized by using the resources that have been devoted to pollution control and rehabilitation for other endeavors. These "opportunity" costs are generally estimated using the prices of abatement equipment, labour and raw materials, but may also include the value of production that may have to be foregone to achieve emission objectives. (3)

One often finds single-valued estimates of the "costs of pollution control" cited in the media (and at the beginning of this paper). These types of cost estimates are useless for policy analysis and decision-making. Abatement costs vary substantially from one source to another. Moreover, at a particular establishment, there are invariably a number of pollution control options and alternatives which can be applied in varying configurations to achieve a wide range of emissions at different costs.

In addition, it is the marginal costs or the incremental costs of achieving successively greater levels of abatement, rather than total costs, that are most relevant for policy analysis. Consequently, in order to make useful comparisons and policy evaluations, the estimation of "abatement cost functions" or "performance functions" is essential. Abatement cost functions are schedules showing the total or the extra costs of achieving increasingly higher levels of pollution control. These data can then be used to compare with incremental benefit data and to assess the impacts on sources.

A third economic dimension concerning acid precipitation is the incidence or distribution of the pollution damages and the costs of abatement and rehabilitation. Information about the distribution of pollution effects is important to assess the equity aspects of the problem. Consideration of the distribution of control costs is also essential to an understanding of the economic incentive structures facing relevant sectors of society, particularly those responsible for NO_x and SO_2 . This information will assist regulatory authorities in predicting whether polluters will resist compliance with abatement orders and it will help these authorities to design policies that can more effectively induce polluters to implement controls.

To reiterate, it is noted that a firm endeavours to allocate its money and manpower in a manner that will maximize the net value of its product, i.e., its profits. By the same token, society's resources should be allocated to uses that will yield a configuration of output that will be of maximum net value to society as a whole. In other words, all sectors of society, government, business and individuals should be attempting to be getting the "best bang for their buck". This is essentially what is meant by economic efficiency. However, one can determine whether a policy or a course of action is efficient only by comparing, in one way or another, the relevant benefits with the costs.

Ideally then, the environmental benefits derived from achieving an environmental improvement should be valued by society equal to or greater than the costs of the goods and services that are given up by society to achieve them. If money and effort must be spent by government or industry to reduce SO_2 emissions or to offset the effects of acid precipitation, other activities such as investment in new plants, research on hazardous chemicals or the upgrading of sewage treatment plants may have to be foregone. It is legitimate, therefore, to ask whether the benefits of reducing or eliminating acid precipitation are worth more to society than the benefits obtained by using the money and effort for some other purpose.

In order to achieve an efficient level of abatement and rehabilitative effort, these activities

should be carried to the point at which the extra benefits are equal to the extra costs. Stated another way, an efficient allocation of resources is achieved when those who benefit from the improvement could potentially compensate all those who incur costs to achieve the improvement.

Distributional equity is achieved when all those who sustain losses from a change in environmental quality are in fact compensated. However, one can be efficient without being fair. A firm which pollutes the environment may generate benefits to individuals and to society at large which exceed the value of the damages it does to the public, to individuals or to other firms, but no compensation actually takes place. Likewise, it would be socially efficient for Inco, Ontario Hydro and U.S. power utilities to spend millions on SO₂ emission abatement if the value of the public and private benefits achieved were greater than the costs of controls even though these firms receive no compensation or remuneration for the abatement.

Questions of efficiency and equity are separate and independent. Economists agree that problems and policies should at least be efficient but decisions about redistribution and compensation to achieve distributional equity involve subjective value judgements and are properly made in the context of public debate and representative votes or referenda.

While cost estimates are generally easier to obtain or generate than information about the benefits of environmental improvements, knowledge of the shape and the magnitudes of the relevant benefit functions are essential to the establishment of rational objectives and the development of effective policies.(4) Without some idea about how benefits change as environmental quality changes, there is a potential for substantial error. As illustrated in Figure 1, the marginal abatement cost function indicates that the extra costs of controls and rehabilitation increase as emission loadings decline. Given uncertainties and lack of information about the effects of acid precipitation, three basically different relationships between the pollution loadings and the damages they cause can be postulated. As we have already noted, the benefits of a control program are the reduction in or the avoidance of damages from pollution.

Curve A implies that damages are not reduced in proportion to emissions. This reflects the problem of reducing pollution sources only in Ontario if most of the acid deposition originated outside the province. Curve B postulates that changes in marginal damages are directly proportional to emission changes. Curve C indicates that there is a threshold effect. At a given level of emissions, damages fall to a low level and do not change even if emissions and deposition are reduced further.

The optimal emission levels for each damage function are noted as Q_A , Q_B and Q_C . If Q_B is chosen as the emission objective but curve C is the correct representation of the damages, society will have wasted $C_B - C_C$ in abatement costs. While it is unlikely that we shall ever be able to determine the optimal level of pollution control with such precision, it is clear that

data on damages and benefits are useful for decision-making.

In addition to providing decision criteria, economic principles are useful in a number of other ways. For example, they provide a framework for evaluating new and existing policies and programs. Benefit-cost analyses force those concerned to explicitly identify and, where possible, enumerate the beneficial and the adverse consequences of different courses of action. Both qualitative and quantitative comparisons of alternatives can be made and assumptions, as well as value judgements, are made explicit for review and comment.

Science and engineering have answered many questions about how and where pollution occurs, what the effects are and how environmental contaminants can be safely treated and disposed. Economic principles, however, help to explain why pollution and other environmental problems occur and to provide a sound rationale for government intervention to protect the environment.

Waste production and external effects are an inevitable consequence of human activity. Whereas the market economy does an effective job of allocating productive resources as well as goods and services efficiently throughout the economy, it fails to prevent excessive waste production, widespread and subtle pollution damages and serious resource use conflicts. The atmosphere and, to a lesser but important extent, surface waters are common property resources and are free to any one on a first-come first-served basis. As long as individuals can discharge waste

products (whether or not these discharges are regulated in quantity or quality) into the environment free of charge and as long as polluters do not bear all of the external costs imposed on others by their activities, the economic incentives established in the market system will favor pollution over abatement. It falls to the government, therefore, to initiate activities intended to stop existing pollution and to protect society from future environmental disruptions. This role is now widely accepted and not even the most rabid "deregulator" would advocate a complete abandonment of this function.

Finally, information about the economic dimensions of acid precipitation help to put this issue in perspective with other pollution problems. It is difficult for most people to compare the physical effects of acid precipitation with those of hazardous waste disposal or sewage treatment effluents. For example, tons of acid wastes being dumped in landfills are qualitatively different from tons of acidic compounds that fall from the skies. However, if the value of damages were known, few people could fail to comprehend and evaluate the dollar value of the damages caused by each pollutant or the value of the costs of reducing these damages.

The next two sections will discuss some of the things that we know about the benefits and the costs of resolving acid precipitation problems. Efforts that are being made to

develop more empirical data and information about the benefits and the costs of resolving this phenomenon will also be described.

3. ASSESSING THE BENEFITS OF ENVIRONMENTAL IMPROVEMENT

The literature on the estimation of environmental benefits has grown over the past five years. Freeman (1979) and Mäler and Wyzga (1976) in particular provide the most comprehensive and complete works to date about the theoretical basis for estimating the economic value of environmental damages and the benefits of environmental improvement. Moreover, the importance of developing empirical estimates of the benefits of environmental protection and pollution abatement is growing for the following reasons.

Over the past two decades a great deal of money and effort has been expended on environmental protection. Consequently, more quantitative information about benefits is required in some cases to justify further abatement and in order to allocate resources and manpower. Environmental assessments require increasingly more explicit information about environmental damages and the benefits improvements.(5)

When investments are made to achieve pollution abatement or environmental protection by individuals, a firm or by the government, two types of beneficial consequences may be produced.

Private benefits are the reduced costs, increased revenues or greater efficiencies that accrue to the party that undertakes the improvement and bears the cost. Private benefits of a pollution control expenditure are generally accounted for by subtracting the extra revenues or the lower costs from the costs of the environmental control measure.

Public benefits are the reduction in the physical damages and effects that impinge on parties unconnected with the polluter, including society as a whole, and that are attributable to the environmental improvement effort. These benefits are further characterized by the fact that firms and individuals who produce public benefits generally cannot capture any remuneration because people cannot be excluded from enjoying them.

The generation of private benefits from environmental investments are more substantial than one might expect. Spokespersons from business and government alike have been quick to dismiss pollution control expenditures as "non-productive", "uneconomic" or yielding significantly lower rates of return than firms require of investments. Moreover, some critics allege that environmental assessment requirements will delay certain industrial developments, particularly in the mining sector. There is, however, growing evidence that pollution abatement programs are producing substantial private benefits and that environmental assessment can save companies millions of dollars.

Royston (1979) has documented numerous examples where pollution abatement efforts have yielded cost savings or profitable by-product recovery. Although we know of no systematic work done in Canada to document the degree to which pollution abatement expenditures produce private benefits, Loucks, Perkowski and Bowie (1979) have described eight large energy related developments that sustained losses because environmental planning and impact assessments were either not undertaken or not heeded.

The value that people and society place on these private benefits is expressed by the market prices of the resources that are saved or the by-products that are recovered and sold. Values of the public benefits are more problematic and difficult to estimate because some of the effects involve activities and environmental resources that are unowned and for which no market prices have been generated. Nevertheless, authorities agree that, assuming people have knowledge about environmental effects, the measure of the value that society places on reducing the adverse effects of pollution is the sum of the amounts that individuals would be willing to pay to achieve the improvement. Alternatively, the total amount that people would require in compensation to voluntarily accept these effects is considered, in theory, to be a measure of the benefit of an environmental improvement.

The benefits that result from reducing acid precipitation or from mitigating its effects are the consequence of three sets of presumed functional relationships. First, changes in the rate of SO₂ and NO_x emissions lead to changes in the deposition rate of acidic compounds in rain, snow and as particulates. Second, changes in the rate of acid deposition lead to changes in the quantity and quality of environmental goods and services that people use. Finally, changes in these environmental services lead to changes in the economic and social welfare as well as the benefits of pollution control efforts.

Consequently, the first step in estimating the benefits of resolving acid precipitation problems is the identification and enumeration, in appropriate units of measurement, of the physical effects of pollution. The physical effects or environmental damages relevant to acid precipitation include one or more of the following:

- (a) Effects of human health.
- (b) Materials damages and soiling.
- (c) Changes in the productivity of ecological systems
 - agriculture
 - forestry
 - commercial fisheries
- (d) Changes in recreational opportunities
 - fishing
 - hunting
 - swimming
- (e) Changes in visibility
- (f) Changes in research opportunities and the legacy to future generations.

Determination of these physical effects is the objective of

the extensive limnological, meteorological and biological investigations being carried out by the Ontario and the federal governments.

Next, the economic values of these effects must be estimated. In theory, these values are expressed as the amount individuals would be willing to pay to preserve and regain environmental features or would require in compensation to sustain losses. Empirical estimates of these values can be made using different methodologies depending on the kinds of effects that occur. For purposes of estimating the economic values of environmental damages, two broad types of values are noted:

- Financial Values
- Amenity Values

The financial value of an improvement in environmental quality may be determined by estimating the amounts of physical damages to goods and services that are bought and sold in markets. Next, these quantities are multiplied by the appropriate market prices to obtain the total value of such damages. With respect to acid precipitation, financial values may be relevant for:

- (a) changes in the damage to or repair of buildings and structures.
- (b) changes in the productivity of forests and agricultural systems.
- (c) changes in the production of commercial fisheries.
- (d) changes in incomes of businesses and individuals that service tourism and recreational activities.

Amenity values include:

- (a) Damages and effects that can be measured physically but for which no widely accepted unit values or prices are established. Examples of these are
 - human diseases and death
 - changes in sport fishing quantity and quality
 - changes in hunting quantity and quality
 - changes in the quantity and quality of other recreational activities.

(b) Damages and effects that are difficult to measure even in physical terms but which have recognized value to people.

- visibility
- aesthetic enjoyment of forests and waters
- the legacy to future generations

The benefits of environmental improvements, as expressed in these empirical methods, are the value of the damages or adverse effects that are reduced or avoided as a result of the environmental protection effort. Thus, which there is agreement about the theoretical basis for estimating the value of these public benefits, no single method for making empirical estimates captures all of the relevant effects or gives equally reliable results. Freeman (1979) systematically describes the many practical difficulties of generating such estimates and the qualifications to which they are subject. Nevertheless, such estimates can, as indicated, constitute useful input to policy analysis, policy development and decision making.

Three inter-related studies will be undertaken by the Ontario government to estimate the economic and social benefits of reducing acid precipitation and mitigating its effects. (6)

(a) Estimation of the Financial Values of the Ecological Effects of Acid Precipitation.

The financial values of those effects that involve goods and services for which market prices are available will be estimated. The categories and sectors which might be susceptible to damages by acid precipitation are listed in Table 1. This exercise will yield a minimum estimate of the economic significance of these effects. It will not capture amenity values derived from recreational uses, aesthetic enjoyment or uses by future generations.

(b) An Assessment of the Economic Significance of Acid Precipitation on Tourism and Outdoor Recreation in Ontario

This study is intended to document the social and economic effects of acid precipitation on tourism and outdoor recreation activities in Ontario and on the firms and organizations (including the Provincial Govern-

ment) that supply goods and services which complement these activities. The significance of these effects, in terms of both physical and economic consequences and as indicated by their social impact and economic value, is to be assessed and the distribution of relevant effects among regions and among groups within the Province will be determined as well.

(c) Estimation of the Amenity and Aesthetic Values of the Effects of Acid Precipitation

There are essentially three approaches to estimate the value of Amenity effects. First, individuals can be asked directly, by means of surveys

- (i) what they would be willing to pay to preserve specific resources or activities or to achieve a specified degree of environmental quality.
- (ii) what they would require in compensation to incur environmental damages.
- (iii) the level or quantity of environmental quality demanded at specific prices.

A second approach is to observe how people alter their consumption and use of goods and services that are complementary to the environmental good or service in question. Thus, if people demand and use more outdoor recreational resources, they tend to spend more on transportation which can be measured.

A third approach is to estimate the effect which changes in environmental quality may have on property values.

The method to be used for this study will be the survey. The second approach will be employed to some extent in the Tourism and Outdoor Recreation Study. The Property Value Approach will not be employed in this initial set of investigations.

The results of the Amenity Value Study will also constitute an input into the Tourism and Outdoor Recreation Study and any overlap between the two investigations will permit verification of the results of each. After suitable adjustments for double counting and for inflation effects on prices, the estimated economic values derived from the three studies can be summarized and added to indicate

- (a) the magnitudes of the value of current and potential levels of damages and effects.
- (b) the manner in which these values might change as acid deposition were increased or decreased.

From these estimates, information and insights about the benefits of possible reductions in acid deposition rates as

rehabilitation efforts can then be generated. These studies will also provide a framework for re-estimations as new or more reliable information about the physical effects becomes available.

4. IMPLICATIONS OF THE COSTS OF POLLUTION ABATEMENT AND REHABILITATIVE ACTIONS

SO₂ emissions are generated primarily from thermal power plants in the U. S. and Canada, from non-ferrous smelters in Canada and from other fossil fuel burning installations in both countries. Nitrogen oxides are generated primarily from power plants and automobiles. According to the U. S. - Canada Research Consultation Group on the Long Range Transport of Air Pollutants (October 1979), total Canadian generation of these pollutants amounts to only about one fifth as much SO₂ as in the U. S. and only 1/10 as much NO_x. There is currently some debate as to the relative contribution by each emission source to the total acid deposition in each jurisdiction. Moreover, Felske (1980) concludes that it is impossible to attribute specific emission sources (polluters) to the acidic compounds being deposited and the damages that are incurred in specific areas. Nevertheless, there is little disagreement among authorities that significant reductions in SO₂ and possibly NO_x emissions are essential to a curtailment of acid precipitation.

There are several important economic issues relevant to the costs of abatement and of measures to offset the effects of acidification. First of all, the thermal power plants and the large non-ferrous smelters that generate the major part of these contaminants face very large costs if SO₂ is to be implemented. These costs give the firms rather large financial incentives to resist and delay abatement actions for as long as is possible.

Second, in order to evaluate alternative control strategies, abatement cost functions must be generated

for each of these facilities. Sufficient public information now appears to be available to do this for Inco.(7) In addition, the Federal government is undertaking a number of investigations about the non-ferrous and the electric power utilities. These studies will, hopefully, provide data and information with which marginal cost or performance functions can be determined for each source.

A third fundamental concern with abatement costs is that virtually all SO₂ abatement costs will be imposed on the private and semi-private (Ontario Hydro) sectors. While these firms can avail themselves of certain tax concessions to mitigate costs, both government and industry have expressed fears that these costs will have adverse economic effects on the firms and on the economy.(8)

At the level of the firm, there are concerns that profitability of the affected firms will decline, plant closures may be precipitated along with lay-offs. Some people are particularly concerned that firms will reduce investment in Ontario. At the level of the economy as a whole, environmental control costs are said to contribute to inflation, slower economic growth, unemployment, and reduced international competitiveness.

In Ontario, we have no record of business closures, changed investment plans, or reductions in employment that have been caused by environmental controls and requirements. Indeed, as long as there are no plant closures, all evidence indicates that compliance with environmental regulations

generally increases employment (Council for Environmental Quality, 1979; Probe Post, May 1978; R. Smith, 1978)

At the macro-economic level, the U.S. Council for Environmental Quality (1979) commissions econometric studies to assess the impact of environmental expenditures.

Briefly, the results of these studies are as follows:

- (a) The overall level of spending for environmental protection is small relative to other expenditure categories. Environmental expenditures are, however, increasing more rapidly than some other categories.
- (b) Environmental expenditures contribute less than 1% per year to inflation.
- (c) The analysis found that the abatement expenditures contributed to a slight increase in employment.
- (d) There was a very slight depressing effect on growth in GNP.

These results were found for the U.S. but there is no evidence to believe that the consequences in Canada would be any different. Here in Canada, the level of public and private expenditure for environmental purposes amounts to about \$3.5 billion per year (Water and Pollution Control, Nov./Dec. 1979). This magnitude is also rather modest when compared with total private investment expenditures or with any other national expenditure measure.

As we have already noted, the very large costs of SO₂ scrubbing devices and process changes give firms such as Ontario Hydro and Inco large financial incentives to implement abatement programs. Moreover, the long range transport nature of acid precipitation gives substantial uncertainty to the benefits of unilateral abatement efforts by individual jurisdictions. Thus governments are reluctant to impose more stringent abatement requirements until everyone is prepared to do so. However, insofar as there is concern about firms' ability to afford these costs, the following comments are offered to give some reassurance.

With respect to Ontario Hydro and most other electric power utilities, the significant economic characteristic of these organizations is that they are monopolies. Consequently, they can, within limits prescribed by the relevant Provincial or State regulatory authorities, pass on all of the added costs of SO₂ removal to their customers. However, there are as yet no publicly available estimates of the costs of air pollution abatement for any of Ontario Hydro's thermal generating establishments with which we can form a judgement about the potential economic impacts.

On the other hand, a firm such as Inco would probably not be able to easily pass on all of the added abatement costs to its customers because it faces competition in its product markets and, presumably, cannot raise its prices whenever it pleases. There is, however, growing evidence that expenditures that will be required to achieve reductions of SO₂ emissions of up to 70% will not have particularly adverse financial consequences for the company (Felske, 1980).

While it is not altogether clear how much SO₂ and NO_x reduction is needed, there seems to be unanimous agreement among the public and governments, that substantial reductions will have to be made by all sources. What is needed for Inco, Ontario Hydro and other sources both in Canada and the United States, are policies that give these sources clear economic signals to implement abatement programs, properly maintain the facilities they install and undertake research to find new and better (ie cheaper) ways to reduce emissions ever further. Such policies are the focus of our closing Section.

Finally, the programs and activities that will likely have to be undertaken to offset the continuing effects of acid precipitation on aquatic and terrestrial ecosystems will also be costly and will very likely have to be undertaken by governments or other public agencies. There are questions of equity to be addressed as well as where the necessary funding will be obtained. The suggestion we make in the next Section will also address these questions.

5. SOME CLOSING OBSERVATIONS AND A SUGGESTION

What can and should we do about acid precipitation? Some individuals and groups have understandably called for fewer studies and more action. A number of suggestions have been made as to the kinds of objectives that should be established and the programs of rehabilitation that should be implemented. Much attention and weight is given to the ratification of a U.S. - Canada treaty on the Long Range Transportation of Air Pollutants as an important step in resolving the problems. However, with or without such a treaty, implementation of abatement programs will depend on the policies and actions of the relevant State, Provincial and Federal governments. Therefore, we must look at policy instruments that the various jurisdictions currently have or could adopt to induce polluters to undertake abatement and, incidentally, finance rehabilitation programs.

By focusing on governmental actions, we do not mean to imply that public interest groups have no part to play in these matters. Time and space constraints permit us only to say that we believe that such groups have an important role. We strongly urge them, however, to consider our suggestions and those of other economists in developing their positions and arguments.

One policy approach that generally finds favor with polluters is the provision of financial assistance to off-set environmental control costs. The Provincial and the federal governments have established an important precedent by providing massive financial assistance grants to the

automotive industry, the pulp and paper industry and, most recently, Massey-Ferguson. It is likely only a matter of time before SO₂ polluters will ask for similar subsidies. In fact, this has already been suggested in a recent Federal government publication (Pearse, January 1980).

In general, economists are critical of financial assistance and subsidies as a means of inducing pollution abatement in the private sector. Such assistance does not provide polluters with a strong incentive to implement abatement and there is virtually no incentive to do research for new, more efficient abatement processes. The misallocation of resources that is caused by pollution is left untouched by subsidies. This means that polluting industries or firms do not pay the full costs of their operations and customers continue to pay lower prices for polluting products than would otherwise be the case.

Nevertheless, financial assistance to certain, adversely affected sectors of society should be considered as part of any comprehensive environmental strategy. However, we believe that financial assistance alone will not provide the necessary incentives to induce firms facing heavy costs to undertake abatement programs in a timely manner. Moreover, such assistance programs will further tax already strained budgetary allocation processes at both the provincial and federal levels. Finally, such programs inevitably raise questions of equity. In any event, the extension of financial assistance to firms and industrial sectors associated with the acid precipitation problem should be preceded by careful assessment and debate.

Because of the coal conversion program in the U.S., the lead time for installation of SO₂ removed devices and the strong resistance to further SO₂ abatement by major stationary sources in Canada, acid precipitation will likely be with us for sometime . Substantial effort, imagination and resources will have to go into "defensive activities" and rehabilitation efforts. Moreover, the magnitude and significance of acid precipitation damages are uncertain although there is no argument as to which sources are contributing to the phenomenon.

Under these conditions, we would suggest that, in addition to the existing policies, Regulations and programs, a Rehabilitation Fee be levied against all-relevant stationary polluters in the US and Canada to be paid according to emissions. The money could be used for rehabilitation and ecosystem repair programs. Such a fee would have to be introduced with the understanding that it would not prejudice the use of other instruments including prosecutions. In addition to providing funds for rehabilitation programs, the fee would at last give polluters a financial incentive to reduce emissions which currently does not exist. To the spurious criticism that such a fee would be a "license to pollute" we must point out that the discharge permits, certificates of approval and administrative orders that are issued by various governments in North America are more appropriately labelled "licenses" and these are all given to polluters free of charge.

At the very least, we would hope that this suggested policy instrument, along with some of the other comments we have made today, will provoke discussion, debate and other innovative ideas for resolving acid precipitation.

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Figure 1. Consequences of Uncertainty About Pollution Damage Functions

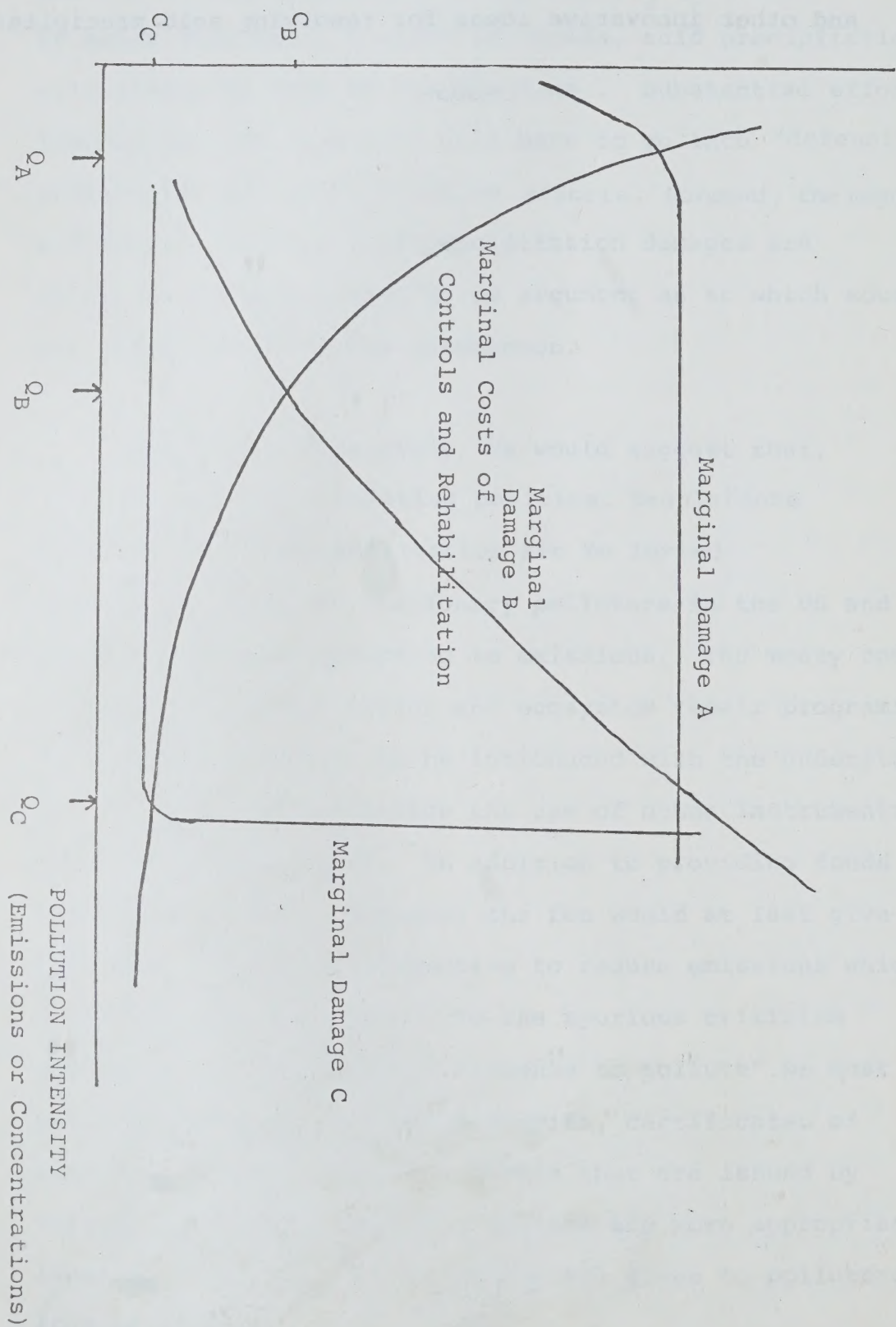


TABLE 1

RECEPTOR CATEGORIES OR SECTORS INVOLVING MARKETED GOODS
AND SERVICES WHICH MIGHT BE AFFECTED BY ACID PRECIPITATION

A. Terrestrial Systems

1. Forests

- a. Pulp and paper
- b. Lumber
- c. Sugar Maple
- d. Fuel wood

2. Wildlife

- a. Commercial Fur
- b. Hides and meat of game animals

3. Agriculture

- a. Crops
- b. Livestock

4. Ornamental Plants

B. Aquatic Systems

1. Fisheries

a. Commercial Fisheries

(i) Food

(ii) Bait

b. Native Fisheries

C. Human Systems

1. Structures and Materials

2. Historical Structures and
Artifacts

3. Water supply

a. Water treatment

b. Corrosion to delivery systems

FOOTNOTES

(1) A massive amount of sulphur compounds found in the atmosphere are of natural origin such as the decay of plants and animals and through the evaporation of seawater sprays. There is some debate among physical scientists as to the primary source of the sulphur compounds that are deposited as acid precipitation. One hypothesis suggests that photochemical reactions in the atmosphere which convert sulphur dioxide to sulphates are induced by nitrogen oxides. Another hypothesis attributes the formation of damage-causing sulphates to bacterial decay in polluted waters. These hypotheses have important implications for policy for if a significant proportion of the problematic sulphate compounds are derived from these sources, then SO₂ abatement may not effectively reduce acid precipitation. See U. S., House of Representatives, Committee on Science and Technology, Review of Research Related to Sulphates in the Atmosphere (Washington, D. C.: U. S. Govt. Printing Office, 1976), pp. 5-9.

(2) Public Goods are goods and services which cannot easily be excluded from consumers. The benefits of National Defence and the adverse effects of pollution are both classic examples. The nature and the implications of Public Goods are analyzed in detail in text books on Public Finance.

(3) For example, Inco claims that the emission objectives in the Provincial Cabinet Regulation that was issued to them in September 1980 will prevent the company from increasing nickel production when market conditions improve and so could impose financial losses on the firm if nickel demand should ever increase. In addition, large SO₂ emitters like Inco and Ontario Hydro have agreements with the Ontario Ministry of the Environment to curtail their operations, hence their SO₂ and NO_x emissions, under certain weather conditions in order to maintain the local "point of impingement" ambient air quality standards.

(4) A benefit function is a schedule showing the benefits to be achieved at different levels of pollution emission or ambient quality.

(5) Many jurisdictions now require economic impact statements prior to the enactment of new regulatory statutes or the promulgation of new Regulations. The generation of information about the benefits of these regulatory activities is an essential component of these exercises.

(6) See Ontario, Ministry of the Environment, "Background Paper on Proposed Socio-Economic Studies of Acid Precipitation" Toronto: Program Planning and Evaluation Branch, July 15, 1980. As of September 1980, two contracts had been let for the Amenity Value Study and the Tourism and Recreation Study.

(7) See Felske, 1980; Environment Canada, 1980.

(8) For a description of the financial assistance programs currently available to Ontario firms, see Ontario Ministry of the Environment, 1980.

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DECREASING SULPHUR DIOXIDE EMISSIONS
FROM INCO METALS COMPANY'S
COPPER CLIFF SMELTER

by

J. Stuart Warner
Vice-President,
Occupational Health
and Environment
Inco Limited

INTRODUCTION

I am pleased to represent Inco at your meeting today. As Grant Mills has said we did not know exactly what we would be presenting at the time abstracts were required. However, we did know that we would be present today, because the by-laws of "Acid Rain Incorporated" say that you cannot have a meeting on acid rain unless you invite Inco. Why is that? I think there are two reasons.

The first is that we emit a very large quantity of sulphur dioxide (SO_2) which, as Mr. Piche has told us, is one of the precursors of acidic precipitation. The second reason is that we have become a symbol of industrial pollution. The symbolism derives from the facts that our Copper Cliff smelter is graced with a 1250 foot tall chimney, the tallest chimney in the world, and that it emits very large quantities of sulphur dioxide, perhaps as much as one per cent of the sulphur dioxide emitted throughout the world. Needless to say, being a symbol -- of anything -- makes life much more difficult.

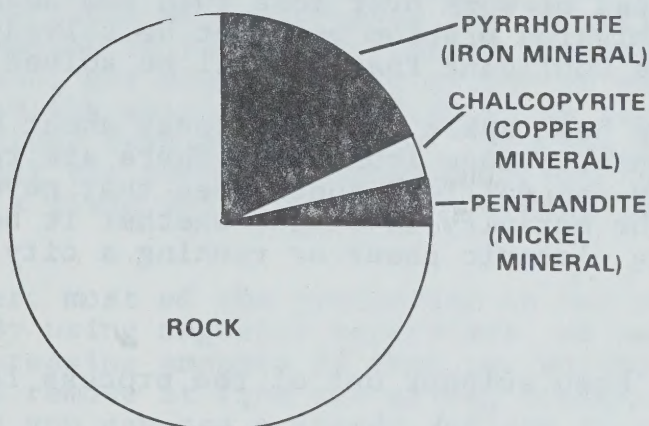
THE NATURE OF INCO'S SO_2 PROBLEM

Why are our emissions at Copper Cliff so large? Is it because we don't care? Is it because we have no idea as to how to curtail them? No, neither of these is the reason. Our emissions are large because of the nature of the ore we must process and because of the large size of our operations in Copper Cliff. Figure 1 shows that three-quarters of the ore is worthless rock; the remaining quarter is composed of sulphide minerals. Three-quarters of the sulphide is pyrrhotite, an iron sulphide mineral containing about 40 per cent sulphur and less than one per cent nickel. One-eighth of the sulphide is pentlandite, the nickel mineral, composed of roughly equal proportions of iron, nickel and sulphur. The remaining one-eighth is chalcopyrite, the copper mineral. It is composed of roughly equal proportions of iron, copper and sulphur. The result of this mineralogy is that we have to mine more than four pounds of sulphur for every pound of copper plus nickel in the ore.

The nature of the ore makes it possible to separate most of the copper mineral into a copper concentrate which contains only a little more sulphur than it does copper. However, the same is not true of the nickel mineral because

Fig. 1

**MINERAL COMPOSITION
OF SUDBURY ORE**



a substantial proportion of it is finely dispersed in the pyrrhotite and because its flotation behaviour is very similar to that of pyrrhotite. We are faced with a constant dilemma in trying to produce a nickel concentrate. If we maximize nickel recovery, we take increased amounts of pyrrhotite into the nickel concentrate feed to the smelter and this results in increased emissions of sulphur dioxide. If, on the other hand, we operate the concentration process in such a way as to maximize the rejection of pyrrhotite, then we could lose large amounts of the nickel mineral. This is not socially responsible either in that it shortens the life of the orebody.

The problem presented by the nature of the orebody is compounded by the large size of our smelting operations in Copper Cliff. In 1977, the last year of uninterrupted operation, our single smelter had to cope with 40 per cent of the sulphur fed to all 15 U.S. copper smelters, 300 per cent of the sulphur fed to all 6 U.S. zinc smelters and 350 per cent of the sulphur fed to all 6 U.S. lead smelters. So our problem is a very large one.

However, we've dealt with large problems before. For instance, we have learned to reclaim our tailings areas. In fact some 1200 acres of tailings have been revegetated and dedicated as a wildlife management area. This achievement did not come easily or quickly. It took a great deal of work over more than two decades. Our sulphur emission problem will not be solved easily either, but we are confident that it will be solved.

I've been asked to speak today about how to prevent environmental damage from SO_2 . There are really only four things you can do; four approaches that never vary regardless of the activity involved, whether it be smelting, generating electric power or running a city. They are as follows:

1. Keep sulphur out of the process feed.
2. Use a process that doesn't convert sulphur to sulphur dioxide.
3. Capture sulphur dioxide and convert it to a non-gaseous form.
4. Emit sulphur dioxide under conditions that disperse and dilute it.

It is obvious that if you were completely successful in any particular step, you would not need to utilize any of the remaining steps. In the real world, I expect that most operations will make use of a combination of several approaches. We have tried all four techniques to control SO_2 emissions from our Copper Cliff smelter but are currently practising only 1, 3 and 4.

Let's go through the options one at a time illustrating what we have done -- and tried to do -- at Copper Cliff.

REMOVING SULPHUR FROM PROCESS FEED

Toronto reduced its SO_2 emissions during the 1970's by lowering the allowable sulphur content of the fuels burned in the city, say from high sulphur coal at one extreme to natural gas at the other. Unfortunately life is not so simple for Inco. We are processors of sulphide ores and we have yet to find a sulphide ore that didn't contain sulphur. Still we have been able to compensate to some extent for this particular "deficiency" of our orebodies.

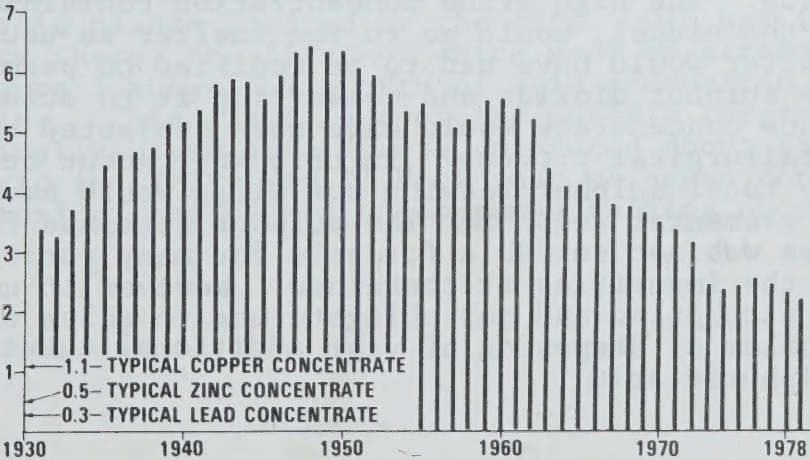
Figure 2 shows the amount of sulphur for every pound of nickel plus copper in the nickel concentrate fed to the smelter. I must remind you that the smelter receives both nickel and copper concentrates. As I said earlier the copper concentrate contains only a little more sulphur than it does copper, and that has been the case since we began using the flotation process for concentration in 1930. The nickel concentrate, on the other hand, got progressively richer in sulphur compared with the metal contained in it as the grade of the ore declined from 1930 to 1950. You can see from the graph that the amount of sulphur in the concentrate doubled for a given metal production during those twenty years.

However, most of the pyrrhotite in our ore is magnetic. By using magnetic separators, we were able to separate increasing amounts of that pyrrhotite from the ore and thus remove it from the nickel concentrate. So from 1950 on you can see a steady decline in the sulphur to metal ratio in that concentrate. Our emissions did not decline in that period because we were increasing production. So this figure is a measure of our efficiency. It shows that by research, development and investment we were able to convert what our grandfathers would have called worthless rock into ore and still minimize the amount of sulphur dioxide emissions coming from the smelter. (One of the questions in our minds now is whether or not research, development and investment can continue to convert rock into ore faster than regulation can convert ore into rock.)

Fig. 2

SULPHUR IN NICKEL CONCENTRATE

(lbs. Sulphur per lb. Nickel - Copper)



The graph also shows the sulphur to metal ratios of typical copper, zinc and lead concentrates. I think our ultimate goal might be to approach a typical copper concentrate but we will never be able to approach the favourable sulphur to metal ratios of zinc and lead concentrates because of the nature of our ore.

Over the years we have learned to separate some 60 per cent of the pyrrhotite from the ore. About half of this goes to the tailings area along with the waste rock. The other half goes to the Iron Ore Recovery Plant. Before we learned to do this, 80 per cent of the pyrrhotite in the ore went to the smelter in the nickel concentrate and the sulphur in it emerged from the smelter as sulphur dioxide. Currently, only about 20 per cent of the pyrrhotitic sulphur ends up as sulphur dioxide.

USE A PROCESS THAT DOESN'T GENERATE SULPHUR DIOXIDE

If you can't keep sulphur out of your process feed, the next best thing to do is use a process which doesn't convert the sulphur to sulphur dioxide. The traditional pyrometallurgical processes unfortunately don't qualify. So instead of oxidizing the nickel and copper concentrates at high temperatures with atmospheric oxygen, we tried to oxidize them at relatively modest temperatures, say 100 to 130°C, using oxygen at high pressure in an aqueous system. The process dissolved some nickel and copper as sulphates and produced an iron oxide/gypsum precipitate, which is analogous to the slag produced in the conventional smelting process. However, much of the sulphur in the concentrates is converted to elemental sulphur instead of sulphur dioxide.

Our intention during this period was to produce a high grade concentrate and a low grade concentrate in our mills. The high grade concentration containing the bulk of the nickel, would go to the smelter as usual. The smelter would have had to be modified to permit capturing the sulphur dioxide and converting it to acid. The low grade concentrate would have been subjected to the hydrometallurgical process. In this way, about one-quarter of the total sulphur leaving our mills would have been converted to elemental sulphur. The sulphur obtained from the process was not suitable for sale for many purposes because of the impurities it contained. However it could at least be stockpiled and not obligate one to solve the large problem of disposing of vast additional quantities of sulphuric acid.

We spent nine years and \$14 million on a substantial amount of laboratory work, two stages of pilot plant development and several evaluations of the hydrometallurgical process. In the end, for a variety of technical, economic and environmental reasons, we decided we could not employ the hydrometallurgical process at this time.

CAPTURE SO₂ AND CONVERT IT TO A NON-GASEOUS FORM

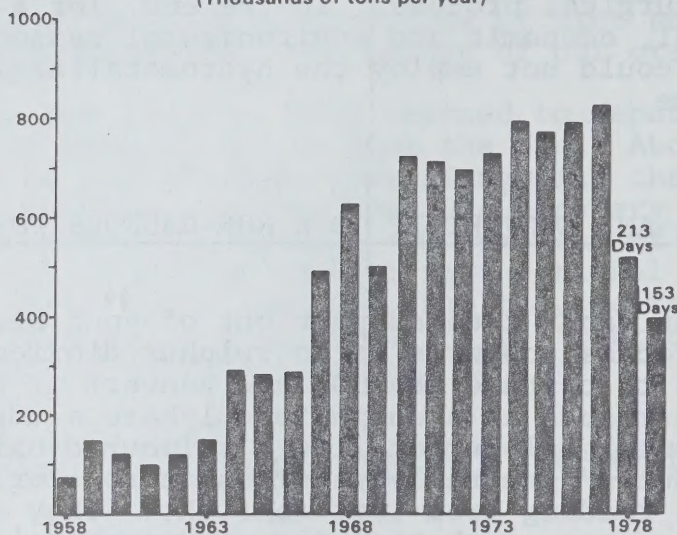
If you can't keep sulphur out of your plant feed and your process converts it to sulphur dioxide, the next approach is to capture the SO₂ and convert it to a non-gaseous form such as a sulphite-sulphate sludge, sulphuric acid, elemental sulphur or liquid sulphur dioxide. Making these "products" generally requires increasingly stronger gas streams reading from left to right. They also have different storage, marketing and environmental problems.

Inco has not seriously entertained scrubbing the gases to produce a sludge for disposal. First of all it would produce very large quantities of waste, which would itself constitute an environmental problem. More importantly this approach goes against our grain as resource people because it takes something that could be useful to mankind and converts it to a waste product. We are rather proud of the fact that we extract 15 elements from the Sudbury ore for man's use.

We have, however, captured large quantities of sulphur dioxide and converted it to sulphuric acid. The fraction of the pyrrhotite which as I mentioned earlier is sent to the Iron Ore Recovery Plant, is roasted and a strong gas containing about 10 per cent SO₂ is sent to CIL's acid plants located at the site. CIL has three acid plants there, the first of which went on-stream in 1958. Figure 3 shows the growth of acid production from this complex. This plant, one of the world's largest metallurgically-based acid plants, produced about 850,000 tons of acid in 1977. You'll note that we began converting sulphur dioxide long before anybody was talking about acid rain.

Fig. 3

**SULPHURIC ACID PRODUCTION FROM IRON ORE
RECOVERY PLANT GAS**
(Thousands of tons per year)



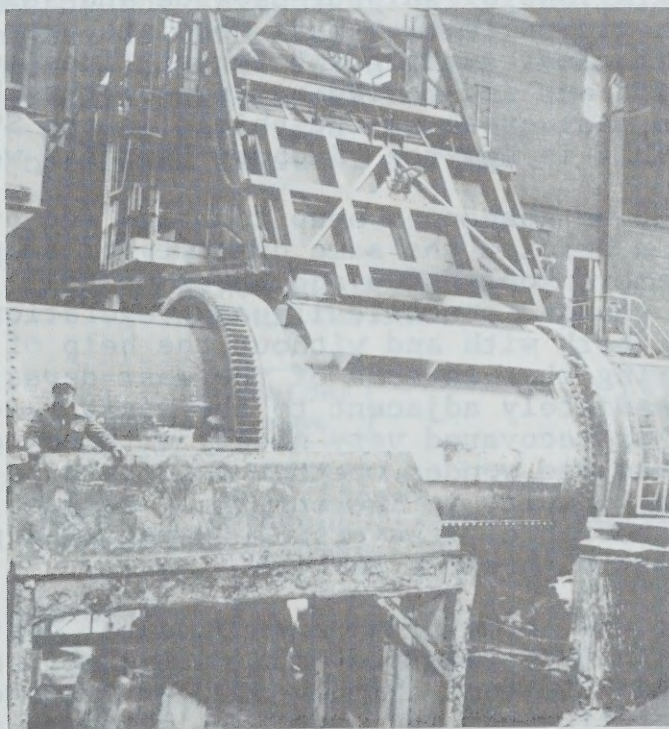
We also investigated the possibility of converting sulphur dioxide from the Iron Ore Recovery Plant to elemental sulphur. In 1958-59 we cooperated with Texas Gulf Sulfur in building and operating a pilot plant which reacted the strong SO_2 gas from the Iron Ore Recovery Plant with natural gas to convert it to elemental sulphur. The conclusion at that time was that it was not economically feasible to do so. Since then the price of elemental sulphur has increased but the price of natural gas has increased far more rapidly.

I think a more telling proof that one cannot afford to make elemental sulphur from sulphur dioxide is the fact that Falconbridge, which successfully operated such a process in the early '70's, abandoned the production of elemental sulphur when it revised its smelter and turned instead to the production of sulphuric acid.

Back in the smelter itself we've also made attempts to capture strong SO_2 gas for fixation. One approach was the oxygen flash furnace, invented and developed by Inco in the early 1950's. This furnace combusts copper concentrate with pure oxygen and yields an off-gas analyzing some 75-80 per cent sulphur dioxide. This is cleaned, sent to CIL who compress it and cool it to produce liquid sulphur dioxide. About 100,000 tons of this product each year go to the pulp and paper industry in Ontario.

About half of the sulphur in the smelter is emitted from the Pierce-Smith converters so we have to find some way to capture this gas. We have spent some \$9 million in modifying three nickel converters and fitting them with water cooled hoods to see if we could improve this capture; that is to contain more gas and to minimize its dilution by air so that it will be suitable for the production of acid. Figure 4 shows a modified converter and hood in the blowing position. The capture of gas is excellent in this operation but unfortunately, the converters blow only about one-third of the time. The overall difference in sulphur dioxide capture from these new hoods is really no different from that of the old hoods. We are currently investigating yet another set of hoods, an outer layer of hooding, to prevent the escape of these so-called "fugitive emissions". But as long as we convert our conventional matte in Pierce-Smith converters, we will have trouble containing these gases and preventing their dilution.

Fig. 4



EMIT SULPHUR DIOXIDE CAREFULLY

If one cannot accomplish the first three objectives then one should at least emit sulphur dioxide under conditions that disperse and dilute it. I know this is anathema to the environmentalists who say "Dilution is not the solution to pollution". I would agree with them that it is not the solution to pollution, but I believe very strongly that it is a solution to pollution. In fact it is a rapid and reliable solution to our most pressing environmental problems.

A classic example is the change in the Sudbury environment produced when heap roasting was abandoned in 1930. Heap roasting was a pyrometallurgical process based on primitive principles which was introduced to the Sudbury area in the late 19th and early 20th centuries. In this process thousands of tons of ore were piled on top of firewood which served to ignite the ore. The ore smoldered for months on end causing extremely high concentrations of sulphur dioxide and sulphuric acid mist at ground level. This obsolete practice, together with clear cutting and forest fires devastated the vegetation and led to the erosion of the thin layer of soil from many areas of the shield in the Sudbury vicinity. This is how the "Sudbury barrens" were created.

In 1930 we abandoned heap roasting and built a smelter which emitted the same quantity of sulphur dioxide through chimneys "only" 600 and 350 feet tall. The environment changed dramatically and vegetation returned to the area, both with and without the help of man. It's very reassuring that in some of the most devastated areas -- those immediately adjacent to the roast yards -- the vegetation has recovered very nicely with no help from man. It makes one wonder whether acid rain, a much milder environmental insult, is indeed likely to lead to that unspeakably horrible, irreversible damage the prophets of gloom constantly threaten us with.

One of the terms of an environmental control order we received in 1970 required Inco to install a still taller chimney. The 1250 foot chimney further improved the quality of air in Sudbury. But tall chimneys are not the only approach we use to improve dispersion. We also go through a rather sophisticated prediction of the meteorological conditions to be expected each day and adjust the smelter output downwards if those conditions are not favourable for dispersion. These conditions occur mostly in the summertime and require us to turn the smelter down on some 40 or 50 days a year.

So to recapitulate, sulphur dioxide control at our Copper Cliff complex is accomplished by three actions:

- rejecting one portion of the pyrrhotite mineral to tailings or stockpile;
- producing sulphuric acid from another portion of the pyrrhotite mineral at the Iron Ore Recovery Plant; and finally
- producing liquid sulphur dioxide from the oxygen flash smelting of copper concentrate.

THE CURRENT STATUS OF EMISSIONS FROM THE COPPER CLIFF SMELTER

Figure 5 shows the distribution of the sulphur that we mine in the Sudbury area. As you can see some 45 per cent of the sulphur is discarded in solid waste products while 25 per cent is converted to saleable products. Thus we contain some 70 per cent of sulphur that we mine and emit only 30 per cent to the atmosphere. Still that 30 per cent is a large quantity and we are committed to reduce it still further.

Fig. 5

ONTARIO DIVISION SULPHUR DISTRIBUTION

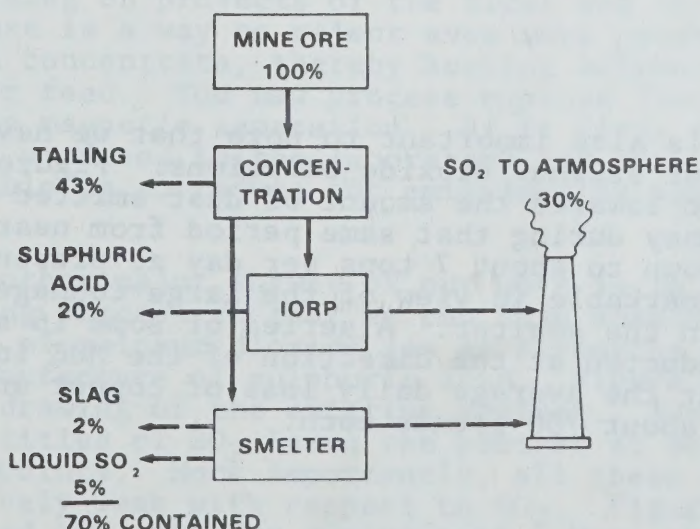
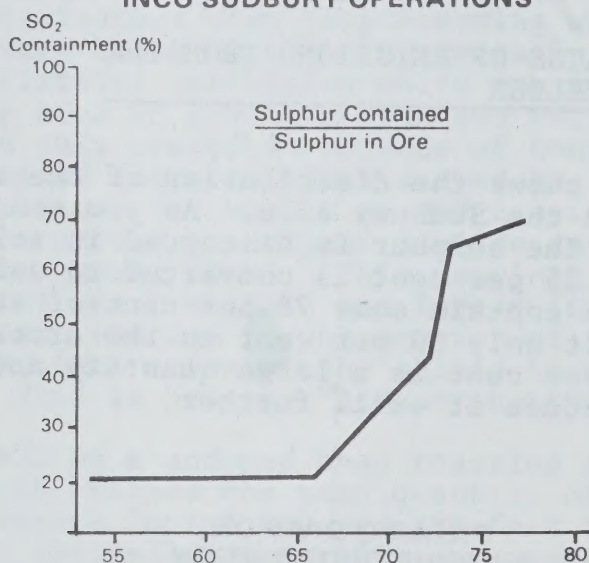


Figure 6 shows that rate at which we achieved that present status. It does not reflect all the little lumps and bumps of our progress of containing sulphur in the ore, but it clearly shows that Inco is on the move. We have a demonstrated record of progress that few if any other large sources can match. For a comparable level of metal production, our present emissions are some 55 per cent less than they were in the 1960's.

Fig. 6

**OVERALL SULPHUR CONTAINMENT FROM
INCO SUDBURY OPERATIONS**

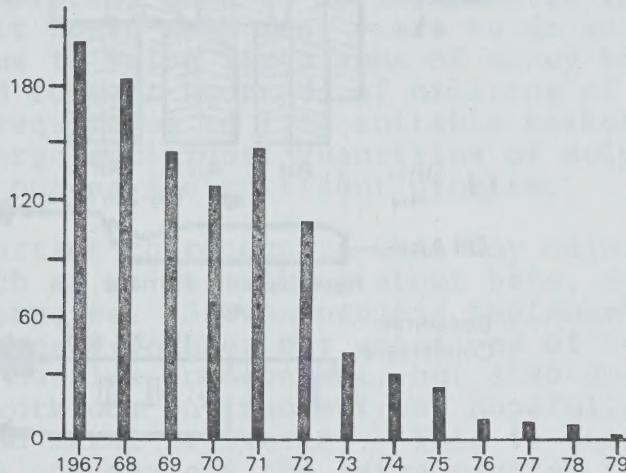


It is also important to note that we have not just reduced our sulphur dioxide emissions. Figure 7 shows we've also lowered the amount of dust emitted from the tall chimney during that same period from nearly 200 tons per day down to about 7 tons per day at present. That's rather remarkable in view of the large tonnage of materials handled in the smelter. A series of some 16 stack sampling tests conducted at the direction of the MOE in 1979 indicated that the average daily loss of copper and nickel was only about 700 pounds each.

Fig. 7

**COPPER CLIFF SMELTER
DUST EMISSIONS**

Dust Tons Per Day



INCO's PLANS FOR THE FUTURE

Where do we go from here? As I have mentioned repeatedly, there are only four ways to prevent damage due to sulphur dioxide emissions from your plant. Inco is now working on projects of the first and third kind. One of these is a way to reject even more pyrrhotite from the nickel concentrate, thereby keeping sulphur out of the smelter feed. The new process employs flotation rather than magnetic separation. If it lives up to the results it produced in the laboratory and pilot plant it should enable us to reduce our emissions by another 25 per cent.

The other major thrust of our work is to revise the smelting process so that we can have access to larger quantities of sulphur dioxide gas at strengths suitable for the manufacture of sulphuric acid. Figure 8 shows a schematic drawing of the existing smelter. Note that large quantities of SO_2 leave the process at several different points. More importantly, all these streams are relatively weak with respect to SO_2 . Figure 9 shows the proposed new smelting arrangement. Note that most of the SO_2 is expected to emerge at one place and at a strength suitable for acid production.

Fig. 8

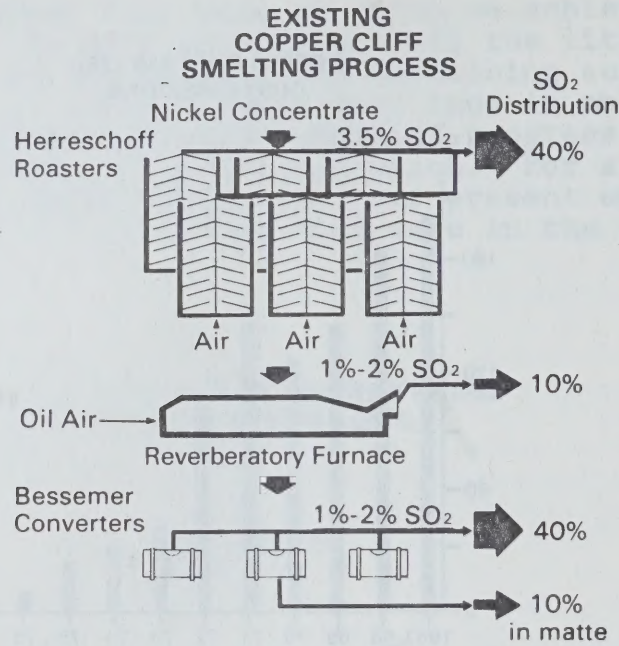
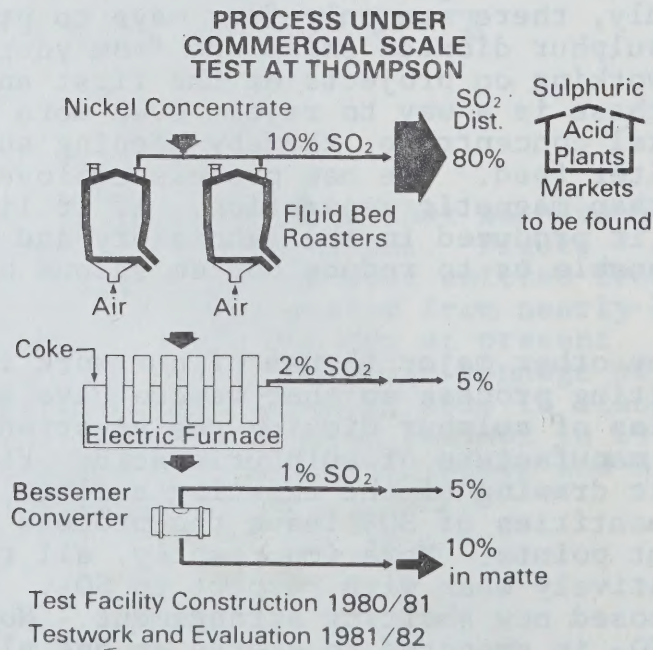


Fig. 9

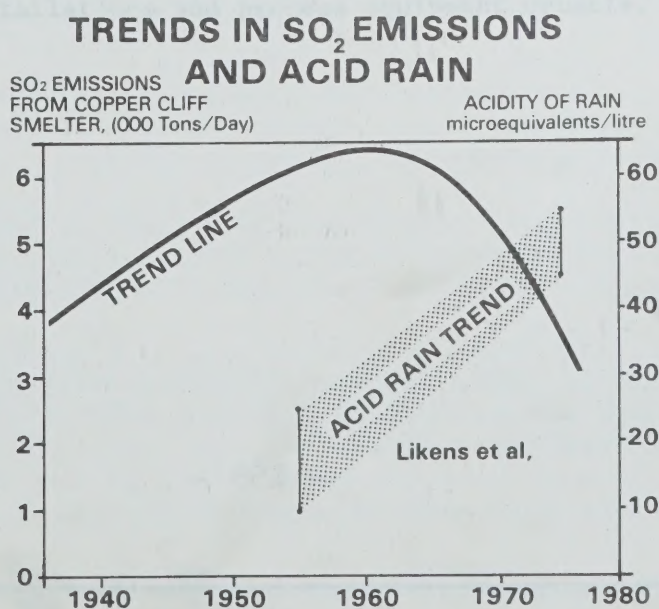


We are spending some \$17 million this year to modify our smelter at Thompson, Manitoba to permit a commercial scale test of the new process in the first half of 1981. We hope to complete a technical and economic evaluation of the process by the end of that year. If this process were to be implemented in Copper Cliff, it would take many years to do so. It would require us to raise large sums of money because it is estimated to cost hundreds of millions of dollars. It would also require us to find suitable markets for disposing of large additional quantities of sulphuric acid. That is not an insignificant problem.

It's important to recognize that any major capital investment, such as we're talking about here, must serve a variety of purposes. So the process implemented has to be one that not only reduces our emissions of sulphur dioxide to the outside environment, but also does something for the workroom environment and hopefully improves productivity and metal recoveries. This is essential if you are to some how pay off the large capital investment required.

Finally, Figure 10 shows that while Inco's emissions have been decreasing, the acidity of rain has been increasing. That's not surprising. Any other producer of SO_2 , who reduced his emissions, could plot a similar graph and say the same thing. However it emphasizes the fact that there are many other emitters out there and that neither Inco nor Ontario nor Canada alone can solve the problem of acid rain in the Sudbury, Ontario or Canadian environment. It will require a continent-wide effort to do this.

Fig. 10



However, I did find a recent statement that Douglas Costle, the administrator of the U.S. EPA made to a sub-committee of Congress on February 27, 1980 to be very interesting. It went as follows:

"Acidity in rainfall from both kinds of acid has grown substantially in its severity and geographic extent since the mid-1950's. *Interestingly, this increase is greater than the proportional change in sulfur and NO_x emissions over this period.*"

This would imply that all emitters of sulphur dioxide and NO_x could reduce their emissions and still not bring about a corresponding decrease in acidic precipitation. This suggests to me that there is a great deal more that we must know before we can effectively address the problem of acid rain.

Yet Inco, which has reduced its emissions substantially in recent years, has made a public commitment to reduce them still further, and has identified technically promising prospects for doing so, has been singled out as a scapegoat for political reasons. Symbolism will not solve the acid rain problem. It must be attacked on a broad front in Canada and the U.S.

We are prepared to do our share.

DAVY S-H PROCESS

A LIME BASED FGD PROCESS UTILIZING FORCED OXIDATION TO PRODUCE STABLE GYPSUM BYPRODUCT

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ABSTRACT

Environmental concerns over limestone sludge disposal and operational problems with scrubber scaling and plugging, in the U.S. and Japan, led to the European development of a second generation flue gas desulfurization process for large scale power stations and industrial plants. The Davy-Saarberg Hoelter FGD process employs a clear, alkaline solution as a scrubbing media which can produce a clean gypsum byproduct suitable for wallboard used in building construction. The first FGD unit was installed in 1974 at a 40 MW demonstration plant. Since then, the system has been successfully scaled up to 175 MW size at a 700 MW coal fired, electric utility power station at Weiher, West Germany. The FGD system has been operating for over one year. The West German Government has since selected this FGD process and has a unit under construction at a 450 MW coal fired power plant in West Berlin; two 150 MW FGD systems will be installed with the first unit to start up in late 1981. The FGD units will produce a gypsum byproduct suitable for wallboard manufacture.

This paper will describe the operating experience, based on actual plant operations, in terms of scrubbing efficiency, onstream performance and capital and operating costs. The process offers proven reliability for SO₂ removal, and can produce an environmentally acceptable gypsum byproduct for sale to the building industry or for cement manufacture. Slides will be presented showing recent power station installations and process equipment details.

DAVY S-H PROCESS

A LIME BASED FGD PROCESS UTILIZING FORCED OXIDATION TO PRODUCE STABLE GYPSUM BYPRODUCT

BACKGROUND

In the late 1960's, Saarbergwerke AG, a large integrated energy company in West Germany, joined with Hoelter GmbH, an engineering firm engaged in pollution control for underground mining and foundries. Saarberg-Hoelter Umwelttechnik GmbH (SHU), the joint venture, was assigned the task of developing an appropriate method to desulfurize flue gases and to design and confirm the feasibility of a large-scale system. After the pilot plant work proved successful, a 40 MW demonstration plant at the Weiher II power station was constructed in 1974. A reliable operation has been maintained. A 175 MW unit for Weiher III was successfully commissioned in March, 1979. The Weiher III FGD system has demonstrated a very high reliability, at 98.7% of boiler on stream time, during the first year of operation from initial start-up. SHU has also demonstrated the process for industrial applications and started up a unit at Veba Chemie AG in December, 1978 to treat the tail gas from two Claus units. SHU has a contract in West Berlin for two 150 MW units with guarantees for 90% SO₂ removal and 95% operability for three years. A 230 MW FGD system in the design phase, is planned to start-up on April 1, 1982 at Voelklingen, West Germany. Davy acquired an exclusive North American license for the process in 1978 and markets the process under the name Davy S-H.

The Davy S-H Process is a wet scrubbing process based on lime. The process has several unique features to distinguish it from conventional lime/limestone processes.

- The use of a clear, alkaline solution (not a slurry) as a washing fluid for absorption of SO₂.
- The addition of a carboxylic acid (usually formic acid) to buffer the washing fluid and control the pH drop during absorption.
- The formation of a water soluble intermediate, calcium bisulfite, Ca(HSO₃)₂, with minimum formation of insoluble calcium sulfite hemihydrate, CaSO₃ • 1/2 H₂O.
- The production of a high grade gypsum (CaSO₄ • 2H₂O) by forced oxidation in an integrated process step. A gypsum grade suitable for wallboard or cement manufacture can be produced.
- The ability to handle chloride containing gases without the need for pre-scrubbing or a liquid purge stream to control chloride concentrations.
- A closed loop system with no liquid waste.

PROCESS DESCRIPTION

Although the Davy S-H Process can handle large quantities of particulates, an electrostatic precipitator or baghouse is recommended upstream of the process to lower the particulate loading of the flue gas to about 0.02 grains/scf. The S-H ROTOPART absorber will further reduce the particulate level to below 0.015 grains/scf which will meet EPA new source performance standard (NSPS) of 0.03 lb/10⁶ BTU for large new steam generators.

The flue gas flows from the electrostatic precipitator, or baghouse, to a booster fan provided to overcome the pressure losses in the scrubber and the ductwork. (Alternately, a single fan could be provided to overcome the total pressure losses in the boiler, ESP and flue gas desulfurization unit.) The use of a booster fan that is forced draft relative to the FGD unit avoids contact with corrosive, wet gases that could result with use of an induced draft fan.

The Davy S-H flue gas desulfurization process, a wet scrubbing process based on lime, has four main steps which are:

Absorption, oxidation, lime and chemical addition, and solids separation.

Calcium ions in the form of calcium hydroxide, $\text{Ca}(\text{OH})_2$, calcium formate, $\text{Ca}(\text{COOH})_2$, and calcium chloride, CaCl_2 , in clear solution are used to absorb sulfur dioxide from the flue gas. The resultant intermediate, water soluble calcium bisulfite, $\text{Ca}(\text{HSO}_3)_2$, is then oxidized to calcium sulfate dihydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, and precipitated from the system as a stable gypsum product. Calcium ions lost with the gypsum are continuously replaced by the addition of calcium oxide, CaO . The gypsum is recovered as a filter cake.

Absorption

From the fan, the flue gas flows to the ROTOPART absorber. In the ROTOPART the SO_2 rich gas stream is contacted co-currently with a clear alkaline washing solution to absorb SO_2 and form the water soluble intermediate, calcium bisulfite, $\text{Ca}(\text{HSO}_3)_2$, which is the only water soluble calcium-sulfur compound. The washing fluid feed normally contain 0.3 gms/liter calcium hydroxide, $\text{Ca}(\text{OH})_2$, 0.8 gms/liter calcium formate, $\text{Ca}(\text{COOH})_2$, and 5.0 gms/liter calcium chloride, CaCl_2 . Chloride increases solubility of $\text{Ca}(\text{OH})_2$.

The ROTOPART absorber consists of one or more absorber tubes sized on a residence time/velocity criteria basis. The velocity should be low enough to allow time for $\text{Ca}(\text{HSO}_3)_2$ formation. The residence time must be low enough to prevent oxidation of the intermediate $\text{Ca}(\text{HSO}_3)_2$ to $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ due to oxygen in the flue gas.

Washing fluid is introduced into each ROTOPART absorber tube by means of hollow cone spray nozzles arranged in one plane. The absorbing tubes function as spray chambers, but have one or more water shedding rings (low pressure drop Venturi throats) to increase velocity and direct the washing fluid back to the center of the duct, thus preventing it from running down the walls as an inactive film.

The shedding rings increase the droplet surface area available for contact and provide the intimate mixing of gas and liquid phases necessary for mass transfer. The contact velocity and the number of water shedding rings required are determined by the SO_2 content of the feed gas and the degree of desulfurization required.

Absorption of SO_2 is achieved by reaction with the active components of the washing fluid which is fed to the rotopart at a pH of 9.5 to 10.5.

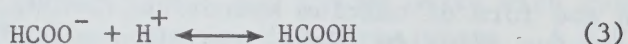


As OH^- ions from the solution are consumed in the absorption of SO_2 , an abundance of H^+ ions are made available.



The pH of the solution drops rapidly to about 5.0.

By removing H^+ ions to form formic acid, HCOOH , the formate ions act to control the pH drop, buffering the solution in the pH range 4.5-5.0, a range that assures formation of $\text{Ca}(\text{HSO}_3)_2$.



Equilibrium is shifted to the right as a result of excess H^+ ions. By controlling the drop in pH, a high SO_2 removal takes place in the pH range 4.0-5.8.

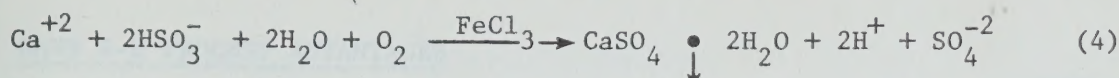
After the formate ion concentration decreases, the buffering effect is weakened and the pH of the washing fluid drops to about 4.0 which is the optimum for oxidation. No pH adjustment is required prior to oxidation.

ROTOPART installations to date included a horizontal centrifugal separator located below the absorber tubes. Development test work is in progress to simplify the system and the desulfurized flue gas will discharge with the washing fluid from the ROTOPART tubes into the oxidizer. A gas space is provided above the liquid for separation of the flue gas from the washing fluid. The flue gas is discharged from the oxidizer through a mist eliminator to the stack. A stack gas reheater may also be required to prevent condensation of a fine mist in the stack.

Forced Oxidation

The oxidizer is a vertical cylindrical tank which functions as a back-mixed reactor. An air blower supplies air which is injected through spargers at the oxidizer bottom at five times the required stoichiometric rate.

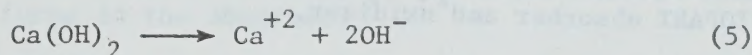
The air converts calcium bisulfite to calcium sulfate dihydrate (gypsum) crystals. Ferric chloride is fed to the oxidizer to provide an oxidation catalyst.



The formation of sulfuric acid, H_2SO_4 , during oxidation reduces the pH of the solution from 4.0 to about 3.5. The crystalline calcium sulfate particles are kept in suspension by the mixing action of the compressed air. The oxidized washing fluid overflows into the mixing channel, a pipe launder, between the oxidizer and the thickener.

Neutralization and pH Adjustment

In the mixing channel, slurried lime, $\text{Ca}(\text{OH})_2$, is added to the washing fluid to replenish calcium ions consumed by the formation of gypsum in the oxidizer and to adjust the pH value to that required for SO_2 absorption.



The sulfuric acid formed in the oxidizer (Equation 4) is converted into additional gypsum.



A small amount of formic acid is added to make up for losses of the calcium salt in the wet filter cake produced downstream and for traces of formic acid vapor with the flue gas from the rotopart. If the flue gas does not contain chlorides, a small amount of hydrochloric acid will also be added. Turbulence in the mixing channel provides thorough distribution of the added chemicals.

Gypsum Separation

The gypsum crystals formed in the oxidizer and mixing channel are separated from the washing fluid in the thickener. The separation is achieved by reducing the fluid velocity below a maximum design level so that individual $\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$ crystals settle to the bottom. The crystals (10-30% slurry) are pumped from the bottom of the thickener to a vacuum filter. The vacuum filter produces a gypsum cake containing approximately 77% solids (23% free H_2O). The dry cake is a high grade gypsum (95-97% $\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$ with less than 0.5% $\text{CaSO}_3 \bullet 1/2 \text{H}_2\text{O}$) with the grade dependent on the quality of the lime supply. The filtrate is recirculated to the thickener. The clear overflow from the top of the thickener is returned to the ROTOPART as washing fluid which provides a closed washing fluid loop.

Gypsum Byproduct Quality

A final process step can be utilized to produce a gypsum grade suitable for wallboard manufacture. The gypsum filter cake is reslurried in a sulfuric acid solution to remove the iron compounds from the cake. The gypsum is dewatered with a centrifuge where wash water is required to reduce the chloride level in the gypsum.

Auxiliary Systems

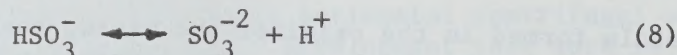
A lime storage and slaking system is provided to prepare and distribute the lime consumed by the process. A combination of clean makeup water and washing fluid are used to slake the lime to a 10 to 20% Ca(OH)_2 slurry. From the lime slurry surge tank the slaked lime slurry is pumped to the mixing channel and mixed with the washing fluid.

Equipment packages are also included for storage and distribution of the following chemicals:

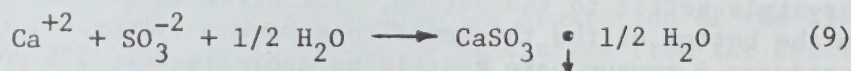
1. Formic acid (90% HCOOH) is added to the mixing channel to provide calcium formate, Ca(COOH)_2 , which buffers the washing fluid pH in the ROTOPART absorber and oxidizer.
2. Ferric chloride (30% FeCl_3), is added to the oxidizer to catalyze the oxidation reaction.
3. Anti-foulant is added to washing fluid samples before the pH meter probes to avoid deposits.
4. Flocculent is provided for use only when there is a high fly ash particulate load.
5. Hydrochloric acid (31.5% HCl) is added to the mixing channel when the flue gas does not contain chlorides.

CONVENTIONAL SCRUBBING SYSTEMS

When SO_2 is absorbed in a conventional wet scrubbing system, an equilibrium between bisulfite and sulfite ions exists.



The calcium ions combine with the sulfite ions to form a precipitate.



The formation of $\text{CaSO}_3 \cdot 1/2 \text{H}_2\text{O}$ creates special problems. Calcium sulfite crystals are very small and do not settle readily. The particles thus circulated through the scrubber can cause a constant maintenance problem to the entire scrubbing system due to erosion and plugging.

Moreover, the resulting "scrubber sludge" is difficult to dewater, has a high COD, and requires a large pond for disposal. Also, the loss of chemicals in solution is high resulting in a high usage of calcium in excess of stoichiometric required.

DAVY S-H PROCESS ADVANTAGES

Calcium Bisulfite Solubility

Most lime/limestone processes require a liquid waste stream to maintain chloride concentrations at an acceptable level. The Davy S-H Process not only tolerates chlorides without corrosion problems, the process is enhanced by them and normally does not require a liquid purge. The presence of chloride ions increases the solubility of calcium hydroxide and other salts. The increased solubility and the use of a buffer allows efficient SO_2 scrubbing to occur at a lower pH than in conventional scrubbing systems. The equilibrium of Equation 8 is shifted to the left with the result that SO_3^{2-} ions are not available to react with Ca^{+2} ions. Thus, calcium sulfite, $\text{CaSO}_3 \cdot 1/2 \text{H}_2\text{O}$, precipitate is not formed, as the water soluble calcium bisulfite, $\text{Ca}(\text{HSO}_3)_2$, forms in the absorber.

Oxidation to Gypsum

Complete oxidation to gypsum is an essential part of the process. Since the washing fluid leaves the ROTOPART at an already ideal pH range for oxidation, the need for an additional acidifying step is eliminated. The formation of the large gypsum particles, compared to fine sulfite particles, allows the liquid to be easily separated from the gypsum particles in the thickener. The clear thickener overflow is recycled to the ROTOPART as washing fluid.

The advantages of not forming a precipitate in the scrubber or circulating a slurry through the scrubber are readily apparent.

- Scrubber recirculation pumps and agitation equipment to maintain a slurry are eliminated.
- Scale formation, incrustation, and the resulting plugging in the scrubber is prevented.
- Erosion in the spray nozzles, lines and pumps and overall maintenance of the system is greatly reduced.
- Power consumption is reduced in the washing fluid loop by circulating less liquid, resulting in a lower L/G ratio.

Gypsum Byproduct

Oxidation to form a stable gypsum has many advantages other than inherent in the scrubbing system.

- Gypsum of saleable quality can be produced. At Bewag Power Station, West Berlin, the gypsum to be produced will be sold to manufacture wallboard and ceiling panels. Gypsum can also be sold as a raw material for cement manufacture.

- Gypsum is easily dewatered and suitable for stacking. If the gypsum cannot be sold, stacking is required, but utilizes only about 60% of the land necessary for sulfite sludge which requires a sludge disposal pond.
- Loss of additives is minimized because of the better dewatering properties of gypsum. The calcium consumption is about 1.02 times stoichiometric.
- Gypsum is chemically stable (low COD) and more environmentally acceptable than calcium sulfite sludge.

Simplicity and Reliability

Operating and maintenance manpower requirements are low due to the simplicity of the process. Operating personnel can be recruited from within the power station.

All equipment in the system is made of carbon steel. Where the equipment comes in contact with a low pH fluid (absorber, oxidizer, outlet gas duct), it is protected with a rubber lining or a thermally hardened epoxy coating to achieve a flexible surface that is resistant to the effects of corrosion and abrasion.

The process has consistently shown desulfurization levels of 90-95% based on one hour averages over a wide range of SO_2 concentrations and fluctuations in flue gas flow. Reliability for the first year of operation has exceeded 98% with no shutdowns due to scrubber plugging.

The automatic control system responds quickly to upsets or load changes to maintain required stack gas SO_2 concentration or percent SO_2 removal.

DAVY S-H PROCESS

Summary of Advantages Over Lime/Limestone Slurry Systems

- Competitive capital and operating costs
- Lower maintenance costs
- Minimum operator manpower
- Simple operation to control
- Reliability proven to exceed 98% without standby units
- SO₂ removal efficiency up to 95% guaranteed
- Modular designed units with 30 to 120% operating range
- No slurries in absorber or agitator for slurry required
- Closed loop system with clear alkaline scrubbing liquor
- Low L/G ratio of 10 to 60 gal/mscf depending on flue gas SO₂ content and percent removal
- Low power demand of 0.5 to 1.5% of total power plant output
- Carbon steel equipment with rubber or epoxy lined absorber and oxidizer
- No corrosion problems
- No scaling or plugging
- No shutdowns for cleaning
- Environmentally acceptable gypsum product
 - No sludge
 - No liquid wastes
 - No additional stabilization
 - No ponds or liners required
- Gypsum stack minimizes land required
- Gypsum product quality suitable for wallboard or cement manufacture
- Minimum loss of chemicals with low water content in gypsum
- Lime consumption is about 1.02 times stoichiometric required

DAVY S-H PROCESS IMPROVEMENTS

Saarberg Hoelter have a development program in progress to optimize the process and reduce costs. Items under investigation are as follows:

1. ROTOPART absorber and oxidizer design
2. Thickener type and size
3. Gypsum drum filter size
4. Limestone to replace lime

DAVY S-H PROCESS

ECONOMICS - U.S. DOLLARS
500 MW UNIT

FGD Unit Design Basis

Coal Fired Power Plant
Coal HHV = 10,500 Btu/lb
Heat Rate = 9,000 Btu/KWh
3.5% Sulfur Coal (dry basis)
Flue Gas = 1,055,900 SCFM
SO₂ Concentration = 0.24 Vol. %
SO₂ Removal = 90%
Absorber Trains, 3-50% Capacity

Capital Cost (Order of Magnitude)

500 MW Unit Installed Cost, Mid-1980 \$45 Million \$90/KW

Direct Operating Costs(1)

	<u>Annual Consumption</u>	<u>Unit Cost, \$</u>	<u>Annual Cost, \$M</u>
Raw Materials			
Lime	66,000 tons	50.00/ton	3,300
Other	--	---	150
Total Raw Materials			3,450
Utilities			
Electricity	45,000,000 KWh	0.03/KWh	1,350
Process Water	100,000 Kgal	0.12/Kgal	12
Steam(W/O Reheat)	60,000 MMBtu	2.00/MMBtu	120
Total Utilities			1,482
FGD Operating Manpower	19,600 man-hr	12.50/man-hr	245
Gypsum Stacking Manpower	43,800 man-hr	12.50/man-hr	548
Analyses	3,220 man-hr	17.00/man-hr	55
Maintenance	--	---	1,350
Total Direct Operating Costs			7,130

- (1) Power unit on-stream time, 6,000 hr/yr. Utility, manpower, and maintenance costs from TVA Report "Economics and Energy Requirements of Sulfur Oxides Control Processes," March, 1979.

DAVY S-H PROCESS

PLANT PERFORMANCE
GERMANY

TEST PLANTS

Pilot Plant for Sinter Belt Off-Gases

Plant capacity 1900 SCFM. SO₂ removal was 90-95% together with high degree of particulate removal.

Demonstration Plant for Flue Gas from 25 TPH Waste Product Incinerator

Plant capacity 19,000 SCFM with simultaneous removal of HCl, HF and SO₂. Removal levels maintained were 98% for both HCl and HF and 90% for SO₂ with wide variations in inlet SO₂ concentration.

COMMERCIAL PLANTS

Saarbergwerke Weiher II

At the Saarbergwerke Weiher II coal fired 125 MW boiler, the S-H Plant treats 85,000 SCFM flue gas, equivalent to 40 MW, approximately 30% of the total flue gas. The unit operated over 20,000 hours with 96% availability.

VEBA Chemie, Gelsenkirchen

The S-H unit is operational at the Gelsenkirchen plant of Veba Chemie. The unit removes 90% of the SO₂ in 22,000 SCFM of combined tail gases containing as much as 13,000 ppmv SO₂ from two Claus sulfur plant incinerators and a sulfuric acid plant.

Saarbergwerke Weiher III

The S-H unit for the Saarbergwerke Weiher III 700 MW coal fired boiler has been in operation since March, 1979. The unit treats 25% of the flue gas, 390,000 SCFM, equivalent to 175 MW. The plant has proven the reliability of the S-H FGD system during the first year of operation with 98.7% on stream availability from initial start-up. The coal sulfur content is 1.2% and required flue gas desulfurization is 80%. The plant has demonstrated 95% SO₂ removal. Power consumption is 1.25% of 175 MW.

The system responds well to load changes with a proven guarantee to handle load changes of 10% per minute with an operating range of 30 to 105%. The mechanical equipment guarantee was for 8,000 hours or 2 years.

A second 175 MW unit will be installed at Weiher III.

Two operators per shift will cover the No. 1 and No. 2 FGD units, as no additional personnel will be required to operate the second unit.

Bewag, West Berlin

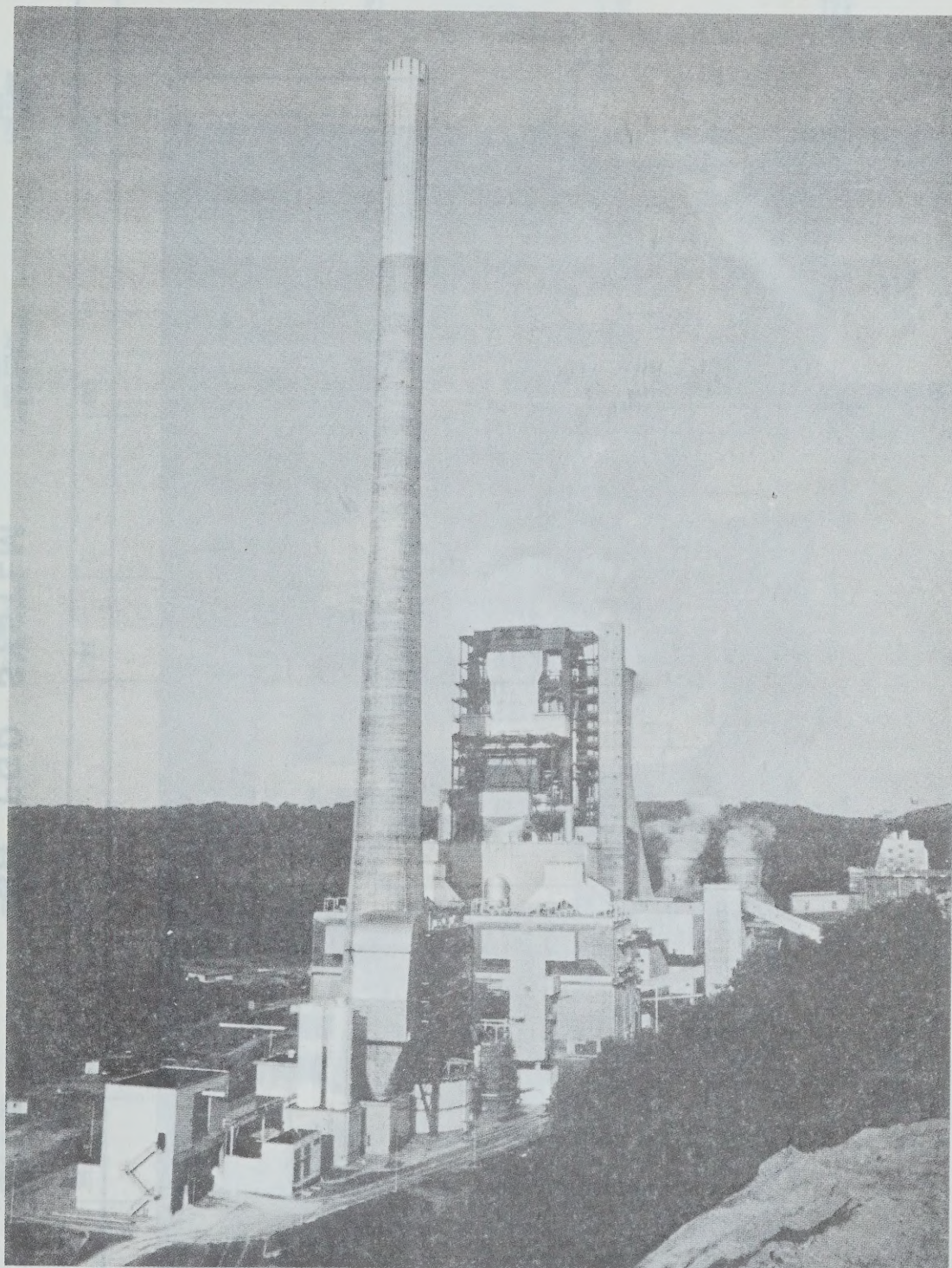
A 150 MW S-H FGD unit, 270,000 SCFM, will start-up in late 1981 and a second identical unit will start-up one year later. The boilers are fired with fuel oil containing 1.4% sulfur. Guarantees include 95% operability for three(3) years with SO₂ removal greater than 90% and 20 to 110% operating range. Guaranteed power consumption is 0.95% for the first unit and 0.87% of 150 MW for the second unit.

The gypsum product will be used for wallboard manufacture which requires the gypsum filter cake to be reslurried with sulfuric acid addition followed by a centrifuge which reduces the free water content to 10%.

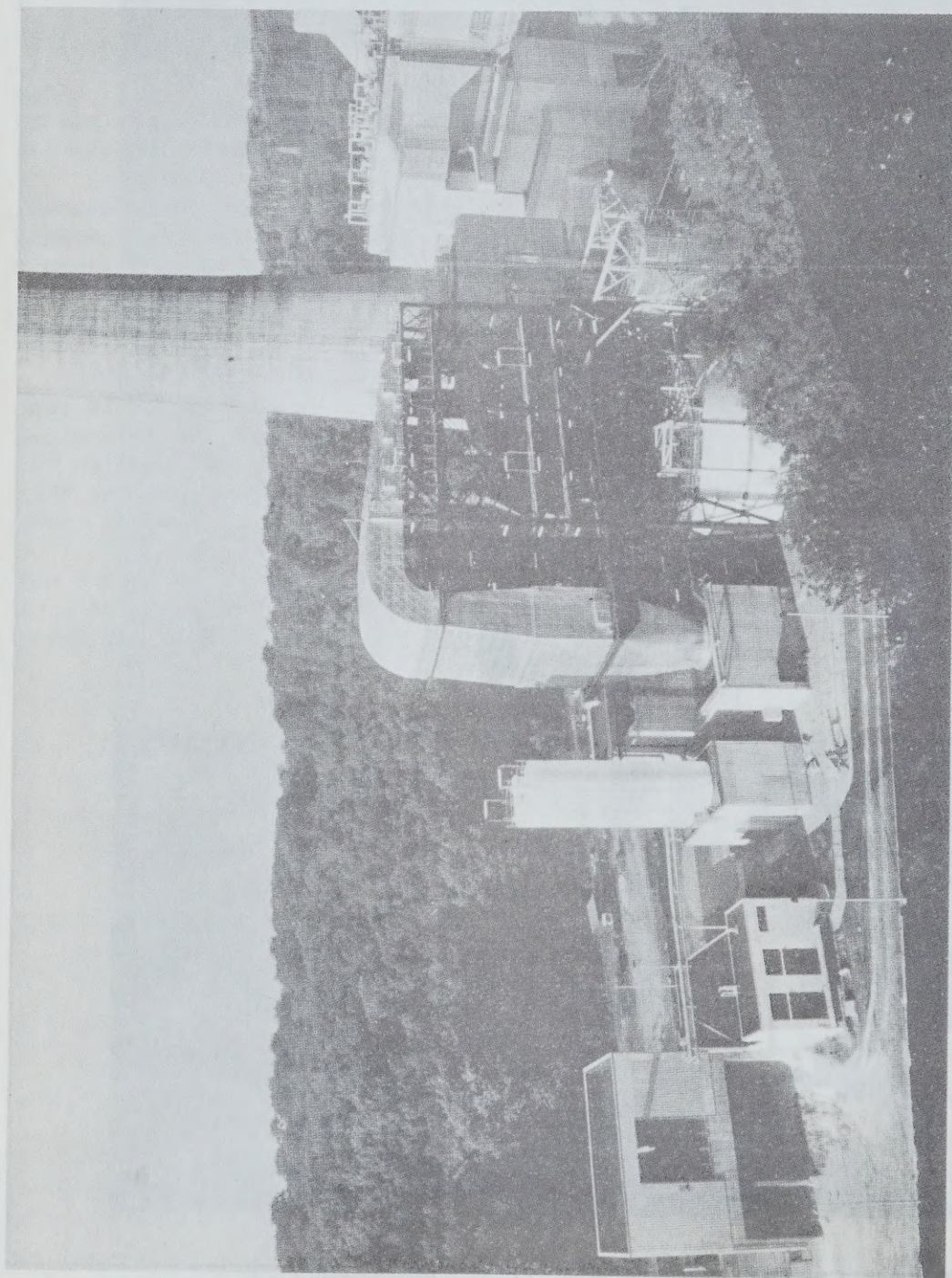
Voelklingen

A 230 MW FGD unit, 515,000 SCFM, is scheduled to start-up April, 1982 at a coal fired power plant. Guarantees include 95% operability for three(3) years with HCl and HF removal greater than 90% and SO₂ removal greater than 80% as required by law. Operating range flexibility guaranteed is 40 to 100% and equipment guarantees are for 8,000 hours or 2 years. Guaranteed power consumption is 1.0% of 230 MW.

The installation arrangement will be unique as the FGD unit will be enclosed in a building in the center of a natural draft cooling tower. Therefore, stack gas reheat and a flue gas stack are not required.

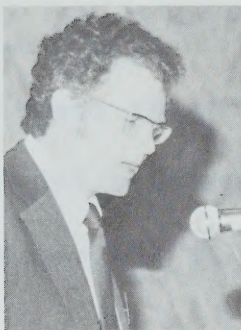


SH FGD SYSTEM
175 MW COAL FIRED UNIT
WEIHER III POWER STATION



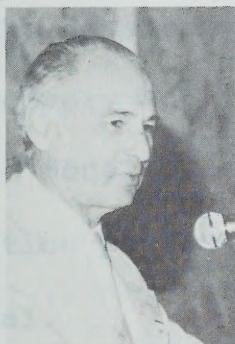
SH FGD SYSTEM
175 MW COAL FIRED UNIT
WEIHER III POWER STATION

SESSION IV
CHAIRMAN



D. P. Caplice

Director
Environmental Approvals Branch
Environment Ontario, Toronto



Safe Disposal of Metal Finishing Treatment Sludges

Kenneth R. Coulter
American Electroplater's Society
Environmental Committee
Scarborough, Ontario

Land Spreading of Refinery Waste Sludges

Dr. D. J. Norris
Research Chemist
Imperial Oil Ltd.
Sarnia, Ontario



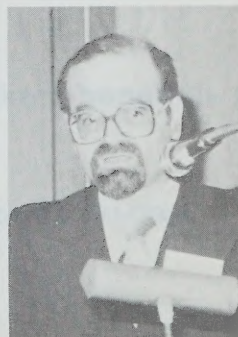
A New Technique for Dust Abatement in a Crushing and Screening Plant

G. B. Warrington
Dust Suppression Manager
Atomization Systems Division
Sonic Development Corporation
New Jersey, N.J.

Note: Paper read on behalf
of author by James Smith.

The Process Design and Eventual Operation of a Wastewater Treatment Plant for a Detergent Manufacturing Complex

Dr. A. Benedek
Associate Professor, Chemical Engineering,
and Co-Ordinator Waste Research Group
McMaster University, Hamilton, Ontario



SAFE DISPOSAL OF METAL FINISHING TREATMENT SLUDGES

by
Kenneth R. Coulter, Environmental Committee,
American Electroplater's Society, Scarborough

With the rapid expansion of effluent treatment in metal finishing plants in North America the concomittant increase of sludges generated by treatment has greatly increased concern for the disposal of these sludges.

With many jurisdictions refusing to accept these sludges in landfill and with the development of regulations in the U.S. and the Resource Conservation and Recovery Act it was seen by industry and U.S. E.P.A. that a study need be done to determine how these sludges would respond to a proposed extraction procedure and how they would behave in a segregated land disposal.

A co-operative agreement was drawn up between the American Electroplaters Society and the U.S. E.P.A.

The A.E.S. appointed a technical director, a task force of knowledgeable people from its membership and an engineering and laboratory company to carry out the project.

The programme had three phases.

- Phase I characterizes chemically and physically the solid and liquid portions of the sludges - 12 representative samples were obtained from industry.
- Phase II was designed to simulate more closely a segregated landfill containing hydroxide sludges.
- Phase III was a field test where soil samples were taken beneath a ten year old sludge bed.

This paper will report on the results and indicate the conclusions drawn from this work.

Note: No formal paper was made available by the author for inclusion in these Proceedings.

by D.J. Norris

INTRODUCTION

Prior to 1978, Imperial Oil's Sarnia refinery disposed of the relatively small quantities of waste sludges primarily through local incineration firms. The introduction of secondary treatment systems, starting in the mid-1970's, however, has increased sludge volumes substantially. Oily sludges consisting of varying amounts of oil, solids in the form of sediment, and water, as shown in Table 1, come primarily from fine-oil-removal processes and cleaning operations. Waste activated sludge, a suspension of bacterial cells from activated sludge plants, represents an equally large volume of sludge requiring disposal. At the same time as sludge volumes have increased, incineration costs have been sky rocketing. Hence, Imperial Oil began to look at alternatives.

In 1976, studies were begun on the use of landspreading (1) as a means for disposal of continuously produced sludges at the Sarnia Refinery. The first study used 10 plots of approximately 100 m² each, to which various amounts of oily sludge and fertilizer were added. This was followed by two studies in 1977: a 0.8 ha area for oily sludge and a 1.6 ha area for waste activated sludge disposal. In 1978, a full scale operation covering 6.4 ha was started up at the

Sarnia Refinery based on the results of these test areas.

Simultaneously, work was progressing at other Imperial Oil refineries and, in 1979, a test site was operated at the Dartmouth Refinery.

Preparations are under way at the Montreal Refinery for a test site to begin operation in 1980. Full-scale landspreading operations will proceed at the Dartmouth Refinery starting in 1980 and are planned for the Montreal Refinery in 1981, subject to approval. The Ioco Refinery has, for several years, successfully disposed of oily sludges using a combined landspreading and composting technique. This paper describes some of the factors which can affect the design and operation of a landspreading site, with particular reference to the results at the Sarnia site.

SITE CHARACTERISTICS

There are many factors which can influence the design and operation of a landspreading site, as listed in Table 2. One of the most important is the climate. Landspreading operations, as with any farming-like activity, are very dependent upon the weather. The frost free period in Eastern Canada averages 7-8 months. However, since soil microbes grow fast only at temperatures above 5°C (2), the effective landspreading period is reduced to about 6 months, from early May until late October. A second significant aspect of the climate is the rainfall. After accounting for days lost because rainfall has made the site too wet to work, only 100 to 120 days are left out of the year for landspreading operations.

The topography and soil characteristics are other factors which must be considered during the design of a landspreading site. The Sarnia site is located on a relatively flat field which had been used for farming in the past. Typical of clay, the soil permeability at the Sarnia site is in the order of 10^{-8} cm/s, lower than is desired for good surface drainage. The cation exchange capacity, or CEC, which measures the capacity of the soil to adsorb cations, is about 30, again typical of clay.

Since soil acts to adsorb the dilute contaminants in water, it is important to have a relatively low water table and sufficient soil cover over the bedrock. Depths of 30 m or more are recommended for the ideal site (3). The 15 m or more depth to groundwater and bedrock, although less than the ideal, is still enough that groundwater contamination is unlikely.

SITE PREPARATIONS

The Sarnia site had previously been used for farming and, therefore, no extensive clearing operations were required. However, the very low soil permeability prevented the soil from drying adequately after heavy rains, as discovered during the 1976 test. The 1977 test area, under which drainage tiles were installed, was much more successful and became a model for the full scale Sarnia landspreading site. Because landspreading can only be carried out for half of the year in Canada, storage facilities must be provided for the winter months. The very low permeability clay in the Sarnia area,

although creating drainage problems for the landspreading site, makes an excellent liner for a storage basin. Each of the two basins dug at the site has the capacity to store one full year's production of either oily or waste activated sludge. An extensive system of roadways was installed, dividing the site into 8 equal areas, 6 for oily sludge and 2 for waste activated sludge. Most of the roadway system was designed for use in good weather only. This acts as a fail-safe mechanism to prevent the inadvertent spreading of oily sludge during adverse conditions. All-weather roadways were only used to permit access to the storage basin areas. The roadways are elevated so that they also function as dikes, thus preventing any runoff from the site.

Seven monitoring wells were installed for sampling the ground water beneath the site. Three of these collect water from a depth of 2.5 to 6 m and the remaining 4 collect water from 1 to 2.4 m below the surface.

OPERATION

The two main processes in the land disposal operation are the spreading, which should give a thin, even layer of sludge, and the tilling, which mixes the sludge into the soil and aerates the soil. Before spreading begins each spring, the site is fertilized with commercial fertilizer at a rate of 110 kg N/ha. Spreading then begins as rapidly as weather and degradation rates permit to ensure that the storage basins are emptied by the next autumn.

Several spreading techniques were tested at the Sarnia site. These included a hand-held hose from a vacuum truck, a liquid manure spreader, an irrigation sprinkler system and a vacuum truck with a spray nozzle. The main features being looked for were thin, even spreading with a minimum of handling. The last method was finally chosen for use at the Sarnia site. Sludge is transferred to the landspreading site by vacuum truck. At the landspreading site, the vacuum truck is fitted with a spray nozzle and the truck then drives up and down the length of the landspreading areas, spraying the sludge out to the side, across the landspreading area. This operation is similar to what can be done with a manure spreader, except the vacuum truck has a larger capacity and, therefore, requires fewer trips. After 6-10 vacuum truck loads ($120-200 \text{ m}^3/\text{ha}$) of oily sludge have been spread on a given area, the area is left to dry for 1-2 days. Within 2 days of good weather, the area has usually dried sufficiently to allow it to be tilled with a disk-harrow. A couple of passes with the disk-harrow completely mixes the oily sludge into the top 15-20 cm of the soil. The same equipment can be used for subsequent aeration of the soil on a biweekly or monthly basis although areas seldom go more than a month before their turn in the spreading rotation comes up again.

The same vacuum truck method is used for spreading waste activated sludge. The activated sludge fields, however, are generally not tilled. The sludge rapidly dries and, within a few months, becomes assimilated into the soil.

MONITORING

Good control of a landspreading site depends upon precise knowledge about the condition of the site at any time. In addition, close monitoring is required to minimize any impact of the site on the general environment. Table 3, lists the parameters which are monitored at the Sarnia site. In the soil, oil content and pH are monitored on a regular basis, no less frequently than monthly. The data are used as operating guides. Further oily sludge additions are stopped whenever the oil content goes above 10%. If the soil pH drops to 6.5, lime must be added to prevent solubilization of trace metals. In addition, a variety of trace metals are monitored in the soil annually, both to follow the buildup of trace metals at the surface of the soil and also to watch for any sign of trace metals migrating into the subsurface soil. Nitrogen and phosphorus levels in the soil are determined at the beginning of each year to ensure that there are sufficient levels of these nutrients to maintain good microbial activity. Ground water collected in monitoring wells is analyzed monthly for a variety of potential contaminants, some of which are derived from the sludge and others which may come from excessive fertilization. A few of the parameters are monitored by request of the regulatory agencies because they are common ground water quality parameters.

Figure 1 shows the seasonal variation of the oil content at the landspreading site in Sarnia. The full scale site began operation in late August 1978. Prior to spreading, the soil contained

approximately 0.1 wt% oil (carbon tetrachloride extractable hydrocarbons). Between late August and mid-October approximately 1400 m³ of oily sludge were spread on the site. This high spreading rate raised the oil content of the site to an average of 8% by the end of spreading. Through the 6 winter months the oil content declined to an average of 6% over the site. Some of this degradation would have occurred on the occasionally sunny day in November with a majority of the decomposition probably taking place between mid-March and the first sampling in early May. Through the month of May, 1979, despite the renewal of spreading, the oil content on the site fell by almost a half to an average of 3.5 wt%. Through June, July and into August, the oil content continued to fall until it reached a minimum of 3 wt% in mid August. Part of the reason for this decline was the fact that the sludge in the storage basins had settled over the winter and the material pumped from the basin in the early part of the year was unusually watery. In almost a duplication of the 1978 phenomenon, the oil content began to rise steeply after mid-August. This probably resulted from a combination of two factors: (1) the cooler, wetter weather in the fall inhibiting the degradation and, (2) by this time of the year, the material being pumped from the basin consisted mostly of the thick heavy sludge which had settled out over the winter months.

The two lower lines in Figure 1 show the oil content of the subsurface soil at 30 and 60 cm respectively. The 30 cm depth lies a mere 10-15 cm below the mixing zone for the oily sludge. Hence, it is not surprising that the oil content has risen somewhat at this level.

At the 60 cm level, no significant increase in oil content has been observed. The clay soil at Sarnia retains the oil at the surface of the soil very well.

Between May and October, 1979, a total of almost 7 000 m³ of oily sludge were disposed of on the Sarnia landspreading site representing a degradation rate of approximately 230 m³ of oil/ha/year. This is a substantial rate considering degradation takes place over only 6 to 7 months of the year (4).

In addition to oil, sludge contains varying amounts of trace metals. Therefore, one would expect trace metal concentrations in the soil to increase as spreading continues. As Table 4 shows, this is indeed what happens. The five metals for which results are given are all of environmental concern and also are typical of the behaviour of the other 27 which are monitored. Sixteen months after the operation began, trace metal concentrations in the surface soil have risen by up to 4-fold. However, concentrations in the subsurface soil are essentially unchanged from the levels observed before spreading began. The data scatter at cadmium concentrations so close to the detection limit makes interpretation difficult at this time; future samples are needed to identify a trend for this metal.

Soil monitoring is used to assist the operation of the site and can also provide a warning of potential contamination, but it is the ground water monitoring which really provides the assessment of the environmental impact of the operation. Contamination of the

ground water could shut down the entire operation. From the long list of monitoring parameters in Table 3, I have chosen three to discuss in more detail: these are oil, phenol and nitrate. The behaviour of these is typical of the other parameters. One group of contaminants which is always of concern is the trace metals. However, trace metal concentrations in the groundwater were generally below detection limits prior to spreading and have remained there since spreading began.

Before spreading began on the Sarnia site in 1978, several groundwater samples were collected from each well. These provide a base case for comparison with subsequent results. Many samples contained undetectable levels of oil, phenol or nitrate, but occasionally high values were observed. There was no detectable difference between the deep wells and the shallow wells at the time.

As can be seen in Table 5, oil and phenol levels appear to have decreased since spreading began. Although this decrease may have a trivial cause, it is quite obvious that, at the very least, oil and phenol are not leaching into the groundwater from the landspreading site. The majority of the other groundwater monitoring parameters in Table 3 similarly show no significant change since spreading began. Although the data in Table 5 are from the Sarnia site, identical results have been observed at the Dartmouth site.

The nitrate concentrations, on the other hand, while unchanged in the deep wells, indicating that nitrate is not leaching deep down towards the groundwater, have tripled in the shallow wells since spreading began. The levels observed in the shallow wells are still well below the drinking water standard of 10 ppm of nitrate-N (5) and do not present an immediate danger, but the results do show that shallow wells can detect potential contamination before it reaches the groundwater. Similar behaviour was observed with ammonia and phosphate, which could indicate excessive fertilization rates (4) on the oily sludge disposal areas or could result from the waste activated sludge disposal. The waste activated sludge contains enough nitrogen to accumulate three times the amount that would result from a normal fertilization rate (4,6,7).

In 1979, a pilot scale landspreading site was operated at the Dartmouth Refinery under quite different conditions: the soil is a fine silt having a much lower cation exchange capacity and a higher permeability, the site is on the side of a hill and susceptible to erosion by runoff water, and the groundwater is within 2 m of the surface. Despite the different site characteristics, the results have been almost identical. Oil and trace metals accumulated in the top 15 cm of soil while the oily sludge was being spread. When spreading stopped, the oil was rapidly decomposed. No increase in oil or trace metal concentrations was observed below the surface 15 cm of soil. Contaminant levels in the groundwater, after spreading, were as low or lower than had been observed prior to spreading. A similar test is being planned at a site in the Montreal Refinery.

CONCLUSIONS

These results show that landspreading can be a viable disposal method for both oily and waste activated sludges, under diverse and sometimes adverse conditions of topography, soil type and climate. Although some landspreading operations use a cyclic operation, in which oily sludges are applied to a level of approximately 8 to 10% oil and then are allowed to decompose to <2% over 2-3 months, we have found that a continuous application method in which fresh sludge is applied every 2-3 weeks works very well. We have achieved disposal rates of >200 m³ of oil per ha per year even though the operation is restricted to 6 months of the year, with sludge being stored for the remaining 6 months. Close monitoring of the site condition is a key to a good operation. Surface soil monitoring guides the operators in making the best use of the areas and preventing overloading of any specific area. Subsurface soil analyses and shallow monitoring wells can provide an early warning of potential contamination before that contamination reaches the ground water. However, we feel that contamination of ground water is unlikely with a properly managed landspreading site, since major contaminants such as hydrocarbons and trace metals are tightly retained by surface soils, even with soils which have somewhat low adsorption capacities. Given a conscientious group of operators and a close monitoring program, landspreading can be an environmentally safe disposal method for most waste oily and biological sludges.

REFERENCES AND NOTES

- (1) A process in which sludge is mixed into the surface soil where naturally occurring microbes decompose the hydrocarbons to carbon dioxide. This process is also known as land farming, sludge farming, biodisposal, land application, land disposal and soil cultivation.
- (2) Alexander, M., "Introduction to Soil Microbiology", 2nd Edition, John Wiley and Sons, New York, 1977.
- (3) Phillips, C.R. and Nathwani, J.S. Water Research, 11, 859-868 (1977).
- (4) Huddleston, R.L., Chem. Eng., 1979, 121-4 (Feb. 26, 1979).
- (5) Drinking Water Objectives published by the Ontario Ministry of the Environment, April, 1976.
- (6) McGill, W.B., Proc. Conference on the Environmental Effects of Oil and Salt Water Spills on Land, Sponsored jointly by the University of Calgary and Alberta Environment, Edmonton, Alberta (Nov. 1975).
- (7) Raymond, R.L., Hudson, J.O., Jamison, V.W., Applied and Environmental Microbiology, 31, #4, 522-535 (Apr. 1976).

(8) Raymond, R.L., Hudson, J.O., Jamison, V.W., AIChE 85th National Meeting, Philadelphia, Pa, June 4-8, 1978.

(9) Knowlton, H.E. and Rucker, J.E., The Oil and Gas Journal, 108-116, May 14, 1979.

TABLE 1

SLUDGE CHARACTERISTICS

	Oily Sludge*	Waste Activated Sludge
Oil Content (wt%)	1-30	<.01
Solids Content (wt%)	1-20	1-10
Water Content (wt%)	50-98	90-99
Trace Metals (mg/kg Solids)	1-10000**	1-10000**

* Primarily from fine oil removal (filter backwash, DAF froth, etc), separator cleanings and tank cleanings.

** Depending on the metal. Aluminum and zinc are among the highest, cadmium and molybdenum are among the lowest.

TABLE 2
SITE CHARACTERISTICS

	Sarnia	Ideal (3, 8, 9)
Climate:		
Frost-Free Days	235	365
Rainfall, May-Oct (cm)	45	
Rain Free Days, May-Oct	130	
Topography	Flat	<1% Slope
Soil Type	Clay	Sandy Loam/Clay
Permeability (cm/s)	$<10^{-8}$	$10^{-3} - 10^{-6}$
CEC (meq/100 gm)	30	>30
pH	7-7.5	>6.5
Depth to Bedrock (m)	>15	>30
>30		
Depth to Groundwater (m)	~15	>30

TABLE 3

PARAMETERS MONITORED

Surface and Subsurface Soil

- Oil Content
- pH
- Trace Metals
- Total Nitrogen and Phosphorous

Groundwaters

- Oil
- Total Organic Carbon
- Phenol
- Trace Metals
- Nitrate, Ammonia, Phosphate
- Chloride, Sulphate, Conductivity
- Total Inorganic Carbon
- pH

TABLE 4

TRACE METALS LEVELS IN SOIL (MG/KG)

	Before Spreading		After 16 Months of Spreading			
	Avg	Range	Surface Soil		30-60 cm Depth	
			Avg	Range	Avg	Range
Cadmium	4.1	1.9-8.4	<7.9	<2.8-19.6	<7.2	<2.2-27.4
Copper	25	13-32	110	77-167	31	15-63
Nickel	28	23-38	52	39-72	33	26-41
Lead	14	11-20	<55	<42-88	<17	<32
Zinc	79	25-92	195	140-265	81	57-116

TABLE 5
GROUNDWATER QUALITY AT SARNIA

	Oil (ppm)		Phenol (ppb)		Nitrate-N (ppm)	
	Avg	Range	Avg	Range	Avg	Range
Before Spreading	0.9	<0.1-3.8	11	<2-20	1.2	<.05-3.0
After Spreading						
Shallow Wells	0.5	<0.1-2.5	5	<2-15	3.8	<.05-10
Deep Well	0.3	<0.1-1.3	6	<2-16	1.3	<.05-5.5

A NEW TECHNIQUE FOR DUST ABATEMENT
IN A CRUSHING AND SCREENING PLANT

AS PRESENTED BY

JAMES A. SMITH

OF

GENERAL SUPPLY division of KESMARK LTD.

INTRODUCTION

In the late 1950s and early 1960s, the public began to awaken to the problem of air pollution. The public was stirred by their awareness of the extremes to which water pollution had progressed in many rivers and lakes, by the increasing perception of visible smog and harsh chemical odours and by medical findings which identified air pollution as a probable cause of many ailments and diseases.

Anti air pollution activities centered at first on the metals industries. Smelters the world over vaporized and condensed millions of tons of potentially hazardous substances. The joint efforts of public and private agencies and most notably, industry itself, have resulted in very substantial reduction in emissions from these plants. Today the metal industry ranks third on the list of industrial particulate polluters contributing only 13.5% to the total of all those emissions. Ranking second is the general category of fuel combustion, contributing 33%. In first place is the crushed stone, lime and cement industry contributing 34% of all industrial particulate emissions. (1)

The problem for the crushed stone industry in complying with these emission standards, is not a lack of existing technology, but rather in finding a technology that is cost permissive without sacrifice to plant performance. The purpose of this paper, is to investigate existing techniques of fugitive dust control and to analyse both the technological and economical aspects, as related to the crushed stone producer.

Let us begin with a review of conventional techniques and then look at a new technique which is both economical and practical for the Crushed Stone Producer.

CONVENTIONAL TECHNOLOGY

A. Fabric Filters:

Fabric Filter Systems normally consist of tubular bags made of woven synthetic fibres in which the dust laden air passes through the fabric while particles are collected on the upstream side by the filtering action of the fabric. The dust retained on the bags is periodically removed by various means and falls into the collection hopper for removal. The fabric filters usually provide very high collection efficiencies in excess of 99%.

Although the use of this type of filter is not generally limited by high temperatures when applied to fugitive dust, there may be a minimum temperature limitation caused by dew point considerations that can cause blinding of bags and therefore high maintenance costs. Typical ancillary equipment associated with fabric filter systems include: a capture device, duct work, the bag house, fans and in those cases where a suction bag house is used, a stack. Special handling procedures must also be allowed for in the disposal of the collected fines.

Bag houses provide high collection efficiencies if they are properly designed with moderate pressure drop, but the initial cost is high. The finer the particulate captured, the higher the energy requirement and the lower efficiency. A Bag House may require considerable space, it may represent substantial maintenance costs and be limited in application to areas which can be enclosed. This precludes its use in such areas as surge and stock piles and loading and unloading areas in the open. An asphalt plant for example, has only one basic point; the dryer, but in a crushing and screening plant, every component can be a potential source.

B. Wet Scrubbers

Wet scrubbers utilize water sprays to collect and remove particulate matter. There are many variations of wet collectors but they are generally classified as low or high energy. Low energy scrubbers include simple spray types, packed towers or impingement plate towers. The water requirement may be three to six gallons per 1000 cu.ft. of gas and collection efficiencies are modest.

The principle mechanisms involved in Wet Scrubbing are:

- (1) increasing the size of the particles by collision and agglomeration with liquid droplets, so that they may be collected more easily and/or
- (2) trapping the particulate in a liquid film and washing them away.

The high energy Ventury Scrubber imparts a high velocity to the gas stream, by means of a converging-diverging duct section, and contact of the dust laden air stream with injected water. The high velocities provide increased collection efficiencies but, the pressure drop may range from ten inches to sixty inches of water. This requires an induced draft fan of very high power input, relative to the gas volume.

A major shortcoming of Wet Scrubbers, lies in the secondary water pollution problem which it creates. Dust laden liquid slurry must be treated in large settling ponds, which must be dredged from time to time.

A secondary fault is that they create a saturated gas stream on the down-wind side which leads to a stream plume on cold or damp days that may be considered unacceptable. Most scrubbers, when used in a conventional way, have a limited capability for controlling fine particulates. This is because most conventional scrubbers depend on some form of inertial collection of particulate as their primary method of capture. Collection efficiency decreases rapidly as particle sizes decrease because inertial forces become insignificant. As a result, it becomes necessary to greatly increase the energy input to improve the scrubbers ability to collect smaller particulate. Even with large energy inputs, the collection efficiency in the micron to sub-micron range is not particularly good. This is important when we consider that the particles ranging in size from 0.1 to 2.0 microns are the ones responsible for visible haze and smog and many respirable diseases. (2)

The ancillary equipment associated with Wet Scrubbers is generally the same as those associated with Fabric Filters. The main difference is in the handling of the collected particulates. Wet Scrubbers suffer from the same application limitations as Fabric Filters.

C. Wet Suppression Systems

Wet Suppression Systems are the least expensive of the three available systems but present problems which make them impractical for most crushing and screening plants. Water is used to dampen the surface area of the product to prevent dust from becoming air borne. This process is not as easy as it sounds, because water tends to agglomerate, which effectively reduces the surface covering capability. As a result, large amounts of water have to be added to the product to achieve full coverage. To overcome this problem, chemical wetting agents are added to the treatment water to reduce its surface tension, so that conventional atomizing nozzles can produce finer atomization. Smaller droplets are generally greater than 50 - 100 microns in diameter and up to 1% of the total product weight must be added to do an effective job.

The primary benefits of Wet Suppression Systems are the low initial costs, ease of operation, effectiveness of dust control in plants where crushing is not performed and where the carryover effect onto stock piles or surge piles and loading facilities is required. These benefits, however, are far out weighed by the draw backs of such systems when applied to a crushing and screening plant.

For example:

- 1) The application of a wetting agent may be precluded by product specification for some critical materials.
- 2) The ineffectiveness of the system when dust is created by a product consisting entirely of fine particles with relatively enormous surface areas.
- 3) When secondary plant product requires fine screens, wetting will cause blinding.

- 4) When water quality is not suitable for moisture with a wetting agent or
- 5) When the product has a greater tendency to absorb moisture.

D. New Technology Requirements

An effective system for the control of fugitive dust in the aggregate industry should achieve the following goals:

- 1) be efficient enough to meet local and federal air pollution codes
- 2) be designed for practicality in the aggregate industry
- 3) have a low initial cost
- and
- 4) carry the lowest initial operating cost

The third and fourth goals are particularly important because expenditures for pollution control are generally not paid back to the producer and therefore cut deeply into the overall profitability of an operation. The three devices that we have just examined do not meet these criteria.

E. Dry Fog Technology

Basic research undertaken at the University in Sweden beginning in 1974 and put into practice in more than 150 installations since that time in Scandinavia, Europe and the United States prove that it was possible to actually filter fugitive dust out of the air, using the extremely fine atomization of water produced by Sonic Core Atomizing Nozzles; without wetting agents and without wetting of the dust source. (3)

At the outset, it was believed that if a sufficient number of water droplets could be produced of approximately the same size as the dust particles, the probability of collision between the two could be extremely high, resulting in a single particle of greater mass that would fall back to its source.

Studies undertaken by the Colorado School of Mines, 1970 - 1976, confirmed these ideas. They found that a water droplet about to impinge upon a dust particle or what is aerodynamically equivalent, a dust particle about to impinge on a water droplet; that when the droplet diameter is much greater than the dust particle, the dust particle simply follows the air stream lines around the droplet and little or no contact occurs. In fact, it is difficult to impact micron size particles on anything, which is why inertial separators do not work well at these sizes.

If, on the other hand, the water droplet is of a size that is comparable to that of the dust particle, contact occurs as the dust particle tries to follow the stream lines thus, the probability of impaction increases as the size of the water spray droplets decreases. This explains why water sprays are not very effective on respirable dust. Typical droplet sizes of 200 - 600 microns are much greater than the respirable dust which is less than 5 microns, thus water sprays can be improved by designing nozzles which produce smaller droplets. (4)

At about the same time, Dr. D.R. Spink of the University of Waterloo, Waterloo, Ontario was carrying on similar studies in a low energy scrubber, utilizing a pneumatic nozzle producing water droplets in the size ranges of 30 micron to 180 micron in size. Dr. Spink came to the same conclusions as the Colorado School of Mines but he made one more important discovery; that a decrease in resistance time did not affect the overall efficiency. His findings were published in June 1976 in the Canadian Journal of Chemical Engineering. (5)

In addition to this particle size theory, the results of the Swedish study indicated that there is another very significant phenomenon which occurs when sonicore nozzles are applied to dust suppression. That effect can be compared to an electrostatic percipitator in which dust particles are charged and then collected on plates of opposit charge. It was found that dust particles created in a crushing plant generally carry a certain negative potential depending on the nature of the dust and the ambient conditions. The water droplets produced by the sonic atomization carry a charge that is strongly positive in relation to the dust particles. The end effect is that probability of a collision between a water droplet and a dust particle is greatly increased from this special probability, implying the need for fewer water droplets to ensure a desired efficiency.

To the aggregate producer, this means that a nozzle generating a dense fog of 1 - 10 micron size droplets, can be used to envelop and smother dust particles at their source and to prevent them from becoming airborne. The only industrially acceptable and available device for producing this dense fog of extremely fine droplets is the Sonicore Atomizing Nozzle.

F. Sonicore Atomizer

This unique patented nozzle is an air-driven device for atomizing liquids by introducing them into a field of high frequency sound waves. The air is accelerated beyond the speed of sound through a convergent-divergent orifice, creating shock waves and passing them into a resonator cavity where they are reflected back to amplify subsequent waves. The result is an intense field of Sonic energy focused between the nozzle body and resonator cavity. Any liquid capable of being pumped into the Sonic shock zone is vigorously shattered into very fine droplets. Because they do not use hydraulic pressure for atomization, Sonicore nozzles operate at very low liquid pressures by incorporating relatively large liquid orifices. In addition, the nozzles are self-cleaning by their sonic nature. Particles larger than the liquid orifices that could cause internal plugging, are filtered out easily.

G. The Dry Fog System

A complete Dry Fog Dust Suppression System is a solution to fugitive dust problems and generally consists of the following components:

- 1) Engineering necessary to place spray nozzles, modify existing equipment enclosures, size and specify piping and wiring and controls to operate the system manually or automatically as a function of customer requirements.
- 2) Custom design spray bars for each individual application point which are easy to install and maintain.
- 3) A centrally located control panel or panels, depending on the system requirements that allow control and tuning of the individual spray points from a central location.
- 4) A compressor facility sized to handle the requirements of the total system and designed for a maximum service life in a particular environment.
- 5) Specially designed piping systems to inter-connect the various components of the system which incorporate thermal installation and electrical heat tracing in colder environments.
- 6) A water filter system that will protect the spray nozzles and other water components from the undesolved solids on most plant water systems.

Each of the above-mentioned components and services are integrated to a total systems concept that will provide highly efficient and low cost operations over a very long service life..

H. Freeze Protection

One of the most commonly asked questions regarding the performance of the Dry Fog Dust Suppression System concerns problems related to cold weather conditions. There are two general areas that must be discussed to properly answer those questions. The first concerns the water droplets when formed and introduced into the sub-freezing condition, and the second concerns the transportation of the water and compressed air from its source to the nozzles.

We are all familiar with snow making machines that are commonly used in ski areas, to produce artificial snow. These machines atomize high flows of water into relatively coarse droplets which then freeze to form a rather dense snow-like material when exposed to the ambient sub-freezing conditions. Most of us also know that clouds exist as tiny water droplets suspend in the atmosphere because of their very light weight. Those tiny droplets, when agglomerated or grown by the condensation of moisture in the atmosphere, become rain drops or snow flakes, depending on the ambient temperature.

Physicists tell us that there is a critical freezing mass for water droplets below which the water will not freeze and above which it will. That critical mass for water is approximately the equivalent of a 20 micron diameter droplet. Since the Sonicore atomizers used in the Dry Fog Dust Suppression Systems are producing droplets in the 1 - 20 micron range, those droplets will not freeze and the dry fog system will continue to operate according to its normal principles. If, however, the water droplets produced by the Dry Fog System are allowed to agglomerate on surrounding surfaces, sheet work, shrouding, etc., freezing will take place, but if a system is properly installed and maintained, there will be no detrimental effect.

I. Supply Lines

As can be seen from the discussion above, the only serious problem that is posed by sub-freezing temperatures, concerns the transportation of the water and air to the nozzle. That problem is overcome in the Dry Fog System by the utilization of a specialized insulation and heat tracing system in conjunction with a post purge system that removes all the water from the water lines and headers, upon shutdown each evening.

J. Installation

The normal scope of supply for a Sonic Dry Fog Dust Suppression System is spelled out in a previous section of this paper. Installation is normally handled by the customer or by his contractor. The installation of the Dry Fog System is generally very simple, it includes setting the compressor on a housekeeping pad in a protected environment; mounting the control panel supplied at a convenient location, preferably in a protected area; installation of air and water lines from the compressor and water source to the nozzle locations by a plumbing contractor; and any modifications for shrouding around the conveyor transfer points or crusher and screens, which can be made from sheet metal, plywood or other substances.

Power must be supplied to the compressor, generally at 550 volts and control panel power at 110 volts. The spray bars are installed at each of the specified locations, mounted on supporting angles, which may require some fitting. All spray bars are provided with mounting brackets to facilitate installation.

K. A Typical Example

A typical aggregate plant producing specification stone and consisting of a primary crusher, a secondary crusher or crushers, screens and transfer points, would require a Dry Fog Dust Suppression System of approximately the following specifications:

specifications:

40 nozzles mounted on the appropriate width of spray bars, water required - 4 gal. per minute, which is equivalent to 6 gal. per hr. per nozzle, total air consumption would be approximately 240 CFM and total power consumption approximately 50 HP compressor or 4.8 CFM per HP.

The cost of that specification would typically run to 10% or 20% of the cost for a similar bag house installation and the operating cost would follow in a similar ratio. The total effectiveness of the system would be in excess of 95% suppression for each of the points, where as the effective ventilation system for the overall plant would probably be lower than that because of the difficulty of hooding and ventilating some of the fugitive dust sources such as screens and stockout conveyors.

At the last stage of the process, the total increase to the moisture content of the bulk material handled would be less than one one-hundredth of 1% and there would be no foreign chemicals added to the material, which would affect its use in any downstream process. The reason for this is simple, only a very small quantity of water is required to suppress the dust of a very high bulk flow rate and the majority of the water used evaporates in suspension or from the product stream.

L. Case History

At the present time, we have no case histories on Canadian installations due to the short period that they have been in operation. However, the National Board of Occupational Safety and Health in Stockholm, Sweden, recorded the following emission concentrations on July 2/76. They were recorded at a limestone processing aggregate plant, utilizing a dry fog system.

All readings are in mg/m^3

<u>Location</u>	<u>Without System</u>	<u>With System</u>
Reclaim Tunnel	5.95	0.80
Crusher Feed	72.63	1.67
Crusher Discharge	192.98	5.22
No. 1 Screen	2.66	0.58
Transfer Point	15.10	1.16
No. 2 Screen	10.80	0.42

Data such as that listed previously, gathered at many installations by the Swedish National Board of Occupational Safety and Health, have proven to them that the Dry Fog System is the most effective system available. They have given their most complete acceptance to the Dry Fog System for use on Crushing and Screening Plants. There are now over 150 such systems operating successfully in Sweden and other countries.

C O N C L U S I O N

The advent of the public's awareness of the need for pollution control has resulted in the formulation of several agencies for the enforcement of current air pollution regulations. These various agencies were forced to demand the use of conventional air pollution devices to meet government regulations. As was shown in this paper, conventional devices were either impractical or cost prohibitive from the producer's stand point. This situation has lead to many stone producers' distrust for government agencies and environmentalists.

However, it has now been demonstrated both in theory and in over 150 installations, that the Sonic Dry Fog Dust Suppression System will satisfy environmentalists requirements for cleaner air, while alleviating the financial burden imposed upon stone producers by expensive and impractical air pollution control devices. The Sonicore Atomizing Nozzle has shown itself to be a useful tool in solving many other pollution control problems and its continued development in these other areas is essential.

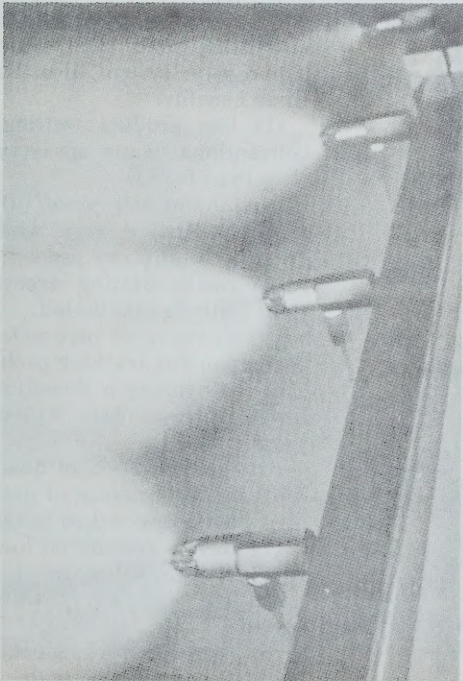
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Dust controlled at source by sonic suppression system

PIT & QUARRY / OCTOBER, 1977

Dry fog application handles wide range of particulate sizes



The sonic atomizing nozzles employed in the "dry fog" dust suppression system are self-cleaning and will not clog. System controls include a sequencing circuit, linear actuators or simple on/off controls depending on site requirements.

When silica, limestone, cement, aggregate and other respirable dust particles ranging in diameter from 0.1 to roughly 70 microns are airborne, they become an occupational nuisance. As a source of physical discomfort, lost materials and wear on conveying pulleys, idlers, belting and motors, such dust is a significant factor in lowered productivity and added operating costs.

One of the more recent successful developments in the industry's campaign to control fugitive particulates is a low cost "dry fog" dust suppression system from Sonic Development Corp., Upper Saddle River, N.J. The system agglomerates dust at the source through a fine spray of thousands of tiny droplets and can be installed at breakers, crushers and other origin as well as transfer points.

A sonic dust suppression system includes Sonicore® atomizing nozzles, a source of compressed air, a sequencing circuit, linear actuators or simple on-off controls depending upon site requirement. The "dry fog" dust suppression system using sonic atomizing nozzles controls respirable particulates 0.1 to 3 microns in diameter and larger airborne particles. These 0.1 to 3 micron "fines" are considered the principal source of dust clouds, haze and accompanying low levels of visibility. In most applications where respirable dust particles can be settled out of the atmosphere quickly, the sonic system makes it unnecessary to add a tension active product to the water.

The sonic atomizing nozzles shatter plain water or water made tension active with chemicals into droplets that are about one tenth the size of those produced by conventional nozzles operating to 100 psi. These micron sized droplets

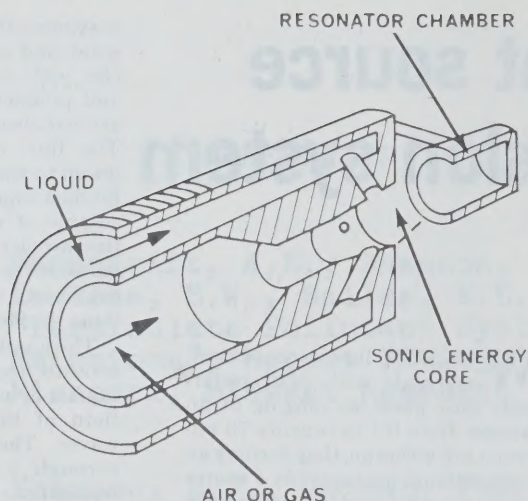
maximize the surface area of the spray and agglomerate dust particles with minimal water volume and product wetting. The nozzles are self-cleaning and will not clog. The fine, adjustable spray produced by the nozzles makes it ideal for dust suppression since the same volume of water in thousands of tiny droplets drifting into a dense particle fog will furnish a great deal more surface area than one large droplet.

The nozzles are gas or air driven acoustic oscillators for atomizing liquids by passing them through a field of high frequency sound waves. The gas or air expands through a convergent/divergent section into a resonator cap where it is reflected back to complement and amplify the primary shockwave. The result is an intense field of sonic energy focused between the nozzle body and the resonator cap.

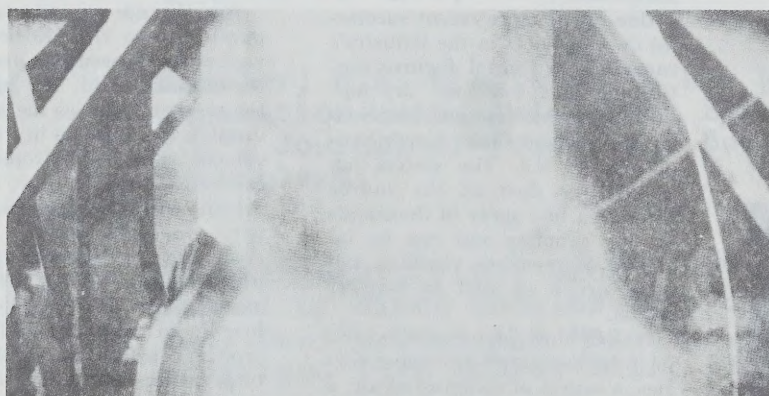
Any liquid capable of being pumped into the shockwave is vigorously sheared into droplets in the acoustic field. Air bypassing the resonator carries the atomized droplets downstream in a soft, low velocity spray. The droplets have low mass and a low forward velocity with low impact characteristics. Inasmuch as they do not create break-up by shearing the liquid through an orifice, sonic atomizing nozzles operate at very low liquid pressures and can be produced with large orifices. The large orifices and low pressure virtually eliminate orifice wear and prevent deterioration of the quality of atomization while greatly extending useful nozzle life.

The greatest advantage of sonic atomizing nozzles is their ability to provide a consistent quality of atomization over a wide flow range. Turndown ratios of 50 to 1 are possible. By varying air pressure, atomization quality can be varied from coarse (50 to 300 microns) to an ultra-fine fog (1-10 microns).

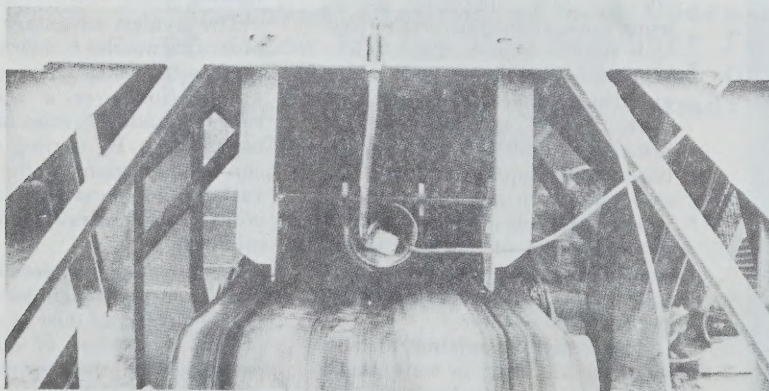
A sonic dust suppression system was given the tough job of suppressing siliceous dust at a quarry producing 100 tons of silica sand each day. With the help of 13 Sonicore nozzles strategically located in the feeding sieves of three Rollercone gyratory crushers, the dust particles are agglomerated and settled down as the silica sand is dis-



Schematic diagram of Sonicore® atomizing nozzle. The nozzles produce a soft, plume-shaped spray with low mass droplets, low fluid velocity and low impingement characteristics. Fine atomization ensures uniform distribution of the liquid with minimum overspray and waste. Large liquid ports prevent clogging or malfunction. Low liquid pressures considerably reduce wear, maintenance and performance deterioration with continuous use. Standard nozzle materials are 416SS and 303SS.



BEFORE TREATMENT — A conveyor transfer point for silica before treatment.



AFTER TREATMENT — Note complete absence of airborne silica dust.

charged from crusher to conveyor. Operation of the atomizing nozzles is controlled by a photoelectric detector which activates the system in the presence of product on the conveyor belt.

Water droplets generated by the sonic dust suppression system are small in size — on the order of 1-10 microns. With a tension active product added at the rate of 1 liter (1.06 qts.) for every 10,000 liters (10,600 qts.) of water, the droplets leaving the nozzle's shock front continue vibrating. This induced turbulence promotes intimate mixing of the liquid with ambient air and dust.

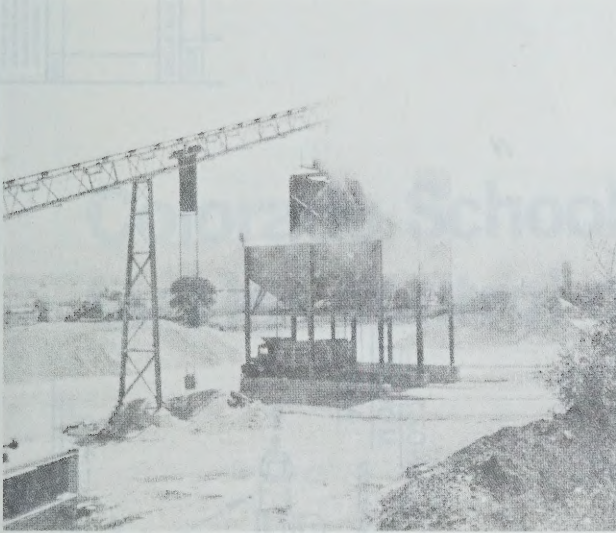
By agglomerating the dust with 200 liters of water every hour — the equivalent of 53 gph, conveyor belt wetting and accompanying tracking problems are avoided. Automatic control of water output is achieved by continuous metering. The volume of water is modified in relation to the humidity content of the pulverized silica.

Total water consumption is extremely low — only 0.2% of production. Water absorption in the product is less than .2%. Self-cleaning action of the nozzles enable them to continuously produce a dense fog of droplets in the face of what would otherwise be a mud encrusting sand. The sonic dust suppression system also provides these benefits:

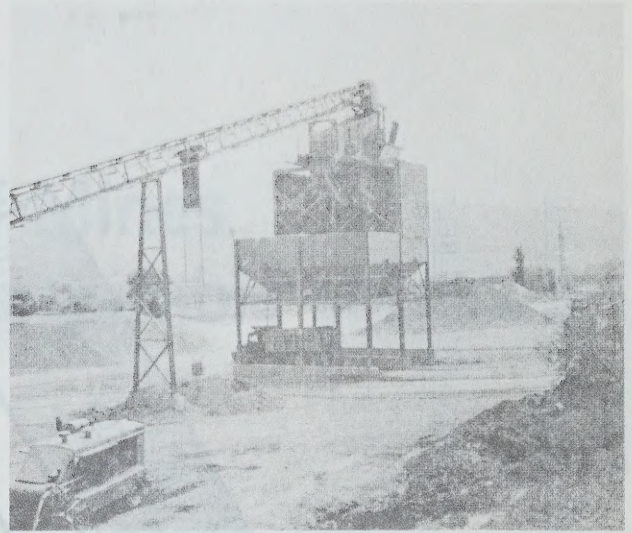
- (1) less product wetting than conventional water spray systems (less than 0.5%);
- (2) micron size water droplets multiply surface area while decreasing total water needed;
- (3) costly wetting agents and their controls eliminated;
- (4) no conveyor belt wetting or accompanying tracking problems;
- (5) less conveyor downtime and fewer conveyor belt replacement parts;
- (6) agglomeration of dust helps improve performance of precipitators, baghouses and collectors;
- (7) nozzles operate on low pressure air and water to eliminate need for expensive pumping systems;
- (8) improved working conditions enables compliance with applicable health and safety regulations;
- (9) cleaning and maintenance costs reduced;
- (10) permits recovery of spilled materials.

Cobleskill Sand and Gravel Cobleskill, N.Y.

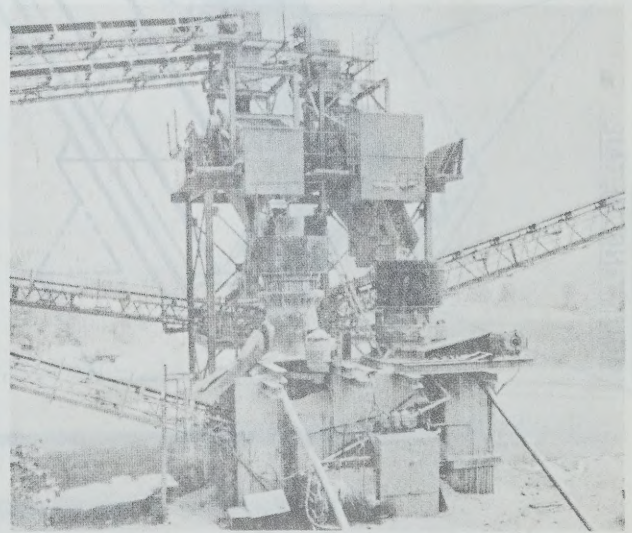
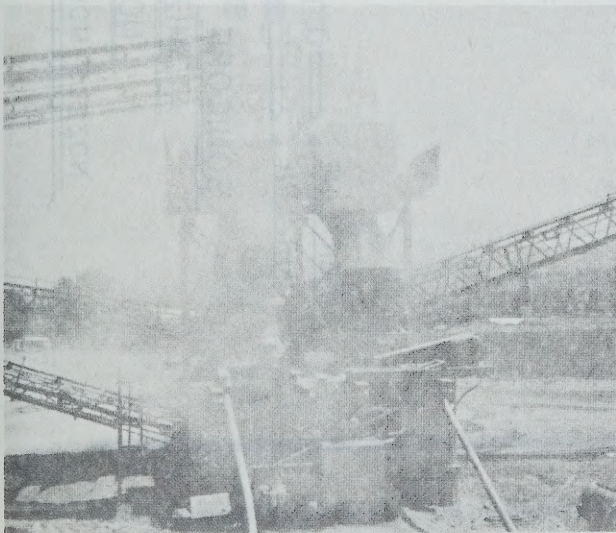
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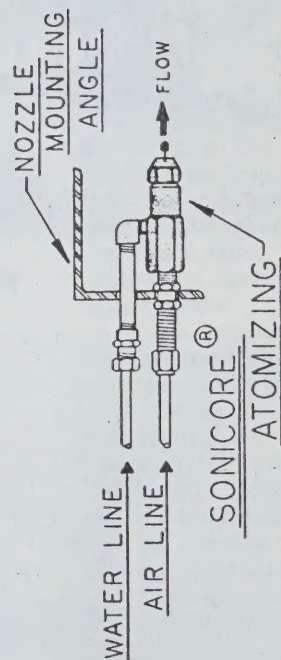
After



Fine Screening and Stock Out



Secondary Screening and Crushing



Esquire
DEVELOPMENT CORPORATION
DIVISION
ATOMIZING SYSTEMS
TITLE STOCK-CUT CONVEYOR
DUST SUPPRESSION
DWG. NO. 50069

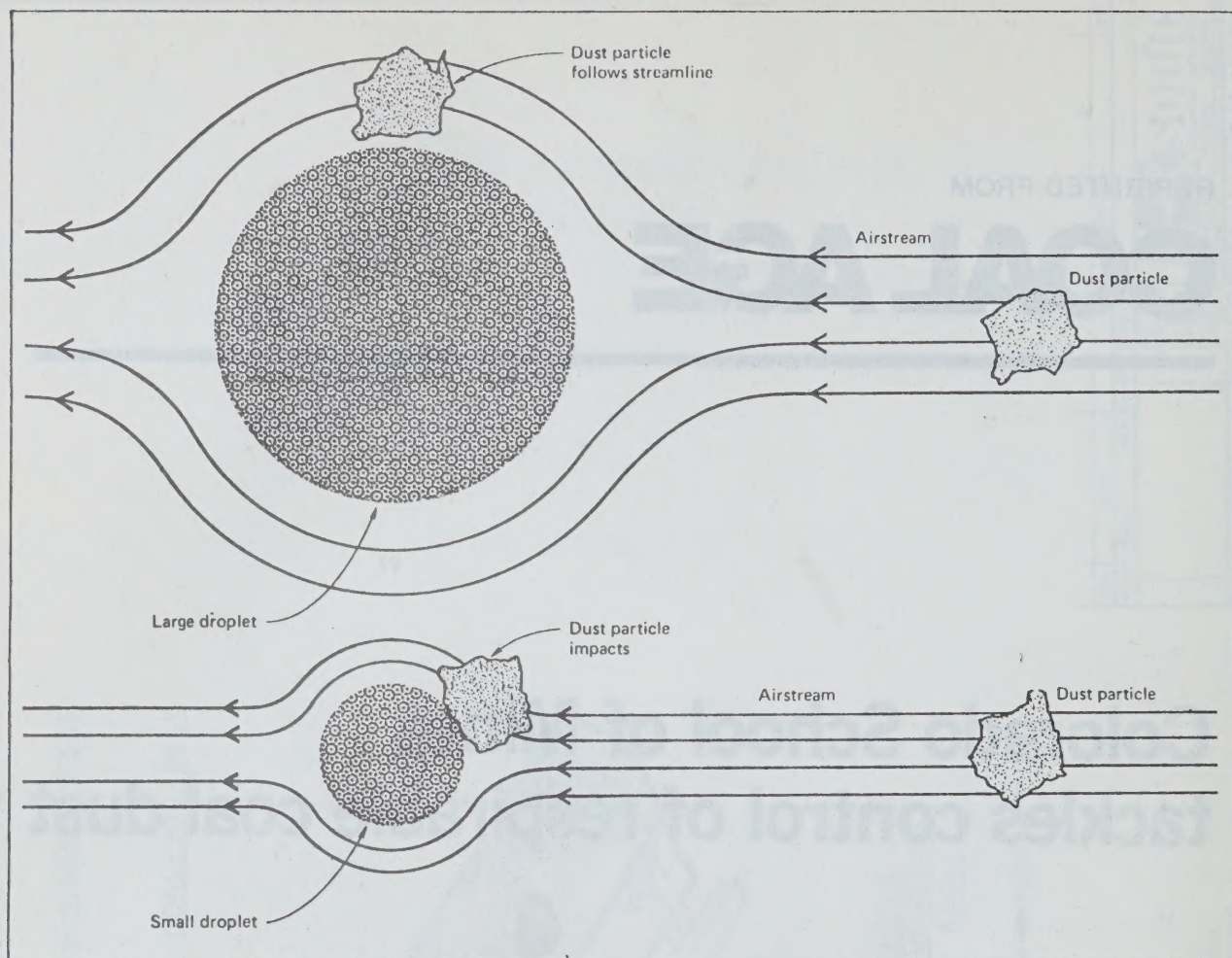
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COAL AGE

Colorado School of Mines tackles control of respirable coal dust

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Airflow around large water droplet (in upper drawing) prevents coal dust particles from contacting the droplet. The dust particle, however, easily impacts a smaller droplet (in lower drawing).

Colorado School of Mines tackles control of respirable coal dust

When water droplets that are sprayed to control coal dust are too large, the dust particles flow around the droplets, and thus are not absorbed—but water droplets too small simply evaporate. So CSM is looking into theories governing formation of clouds to improve existing water spray technology.

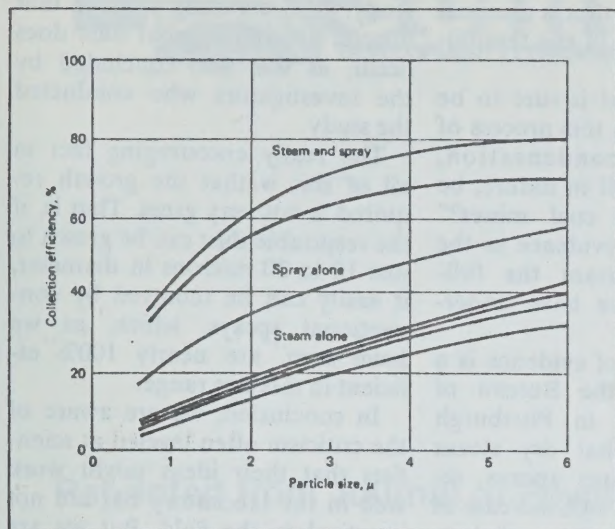
F.D. Schowengerdt and J.T. Brown, Colorado School of Mines

EXPERIENCE GAINED over the years with water sprays has established the following facts: (1) For a given spray nozzle, the collection efficiency for small dust particles increases as the pressure increases,

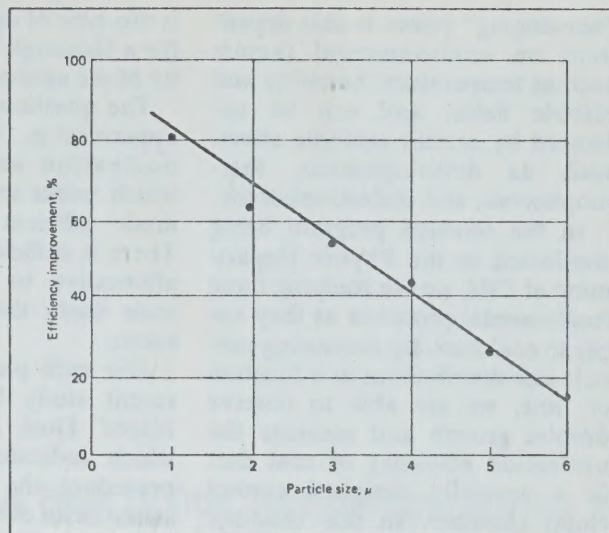
and (2) at a given pressure, the efficiency increases as the nozzle design is changed so as to produce smaller droplets. The conclusion is clear-cut—the smaller droplets are more effective in knocking small

dust particles out of the air. The reason for this is not hard to see.

Consider a water droplet about to impinge on a dust particle, or what is aerodynamically equivalent, a dust particle about to im-



Steam-spray combination is more efficient in collecting dust than either steam or spray (from Cheng and Emmerling. USBM Report of Investigation 7819).



Efficiency of steam-spray over spray alone is much more pronounced in the smaller particle sizes (also from USBM RI 7819).

pinge on a water droplet, as shown in the drawing. If the droplet diameter is much greater than the dust particle, the dust particle simply follows the airstream lines around the droplet, and little or no contact occurs. In fact, it is difficult to impact micron-size particles on anything, which is why inertial separators do not work well at these sizes.

If, on the other hand, the water droplet is of a size that is comparable to that of the dust particle, contact occurs as the dust particle tries to follow the stream lines. Thus the probability of impaction increases as the size of the water spray droplets decreases.

This explains why water sprays are not very effective on respirable dust: typical droplet sizes are 200

to 600 microns—much greater than the respirable dust, which is less than 5 microns. Thus, water sprays can be improved by increasing pressure or by designing nozzles which produce smaller droplets. Most of the improvements in this direction already have been made. The problem with this approach, and one which prevents much additional improvement, is that when very small water droplets are introduced into an atmosphere where the humidity is less than 100%, many of them evaporate before contacting the dust particles.

Condensation theories

With these facts in mind, we are led, through the logical extension of our approach, to smaller and smaller droplet sizes, all the way to

the vapor phase, extending the relative humidity above 100% and condensing the water directly onto the dust particles. In this way, the particles can be made to grow, under the proper conditions, to a size where they will either fall out or can be removed by sprays.

As soon as we take this step, we are in an area of physics known as "cloud physics" and can draw on the tremendous volume of scientific research results that exists in this area. For example, for over 20 years the US Atomic Energy Commission has studied the basic processes by which radioactive fallout from bombs and reactor accidents is naturally removed from the atmosphere. The fundamental processes involved are nucleation and condensation.

Nucleation is the process by which raindrops are formed in clouds. There are two categories: homogeneous, where no foreign particles are present; and heterogeneous, wherein the droplet formation takes place on foreign particles. The efficiency of the latter depends on many factors, such as particle solubility, wettability (hydrophobic or hydrophilic), the presence of hygroscopic salts, temperature, electric fields, charge and others (see Table 1).

After nucleation occurs, the droplets must grow to a critical size where they will fall out or can be washed out. The efficiency of this

Table 1—Factors affecting the efficiency of water-droplet formation

- | | |
|---------------------------------|---------------------|
| ■ Particle size | ■ Charge |
| ■ Particle solubility | ■ Temperature |
| ■ Particle wettability | ■ Relative humidity |
| (Hydrophobic or hydrophilic) | ■ Pressure |
| ■ Presence of hygroscopic salts | ■ Electric fields |

"scavenging" phase is also dependent on environmental factors such as temperature, humidity and electric fields, and can be enhanced by certain catalytic effects such as diffusiophoresis, thermophoresis, and dielectrophoresis.

In the research program being conducted in the Physics Department at CSM, we are studying these fundamental processes as they apply to coal dust. By measuring particle size distributions as a function of time, we are able to observe droplet growth and measure the nucleation efficiency of coal dust in a specially designed aerosol cloud chamber. In this chamber we can simultaneously control all the pertinent environmental factors as well as the particle residence time. Thus we can predict the time required for a given size dust particle to nucleate and grow to a given size in a given humidity.

We also can take measures designed to enhance the efficiencies, such as modifying the particle properties, adding hygroscopic salts and wetting agents, and introducing charges on the particles. It

is this type of input that is essential for a thorough test of the feasibility of the method.

The question that is sure to be uppermost is, "Can this process of nucleation and condensation, which works so well in nature, be made efficient in coal mines?" There is sufficient evidence in the affirmative to warrant the full-scale study that we have undertaken.

One such piece of evidence is a recent study by the Bureau of Mines' Dust Lab in Pittsburgh which indicated that dry steam preceding the water sprays resulted in an overall 14% increase in collection efficiency for coal dust. Ironically, the conclusion drawn from these results was that steam did not offer a significant improvement. But if one looks carefully at the data shown in Figs. 2 and 3, it will be seen that an improvement of nearly 100% occurs at particle sizes of 1 micron and less. This is indeed a significant improvement when one considers the importance of this size region, and is enough to justify a more detailed

study. It is certainly evident that droplet growth on coal dust does occur, as was also concluded by the investigators who conducted the study.

The really encouraging fact in all of this is that the growth required is not very great. That is, if the respirable dust can be grown to just 10 to 20 microns in diameter, it easily can be removed by conventional sprays, which, as we have seen, are nearly 100% efficient in this size range.

In conclusion, we are aware of the criticism often leveled at scientists that their ideas might work well in the laboratory but are not practical in the field. But we are also aware that not many real breakthroughs in science or engineering have occurred that were not preceded by extensive basic research. In this particular case the approach we are taking offers a great possibility of improving existing water spray control technology by drawing on existing knowledge from the field of cloud physics, and applying this knowledge to coal dust. ■

New laboratory

During the past year, a Particulate Science Laboratory has been under development in the Physics Department at the Colorado School of Mines under the direction of the authors. The laboratory has been made possible through a series of gifts and grants from several interested companies and agencies. Initial funding came from gifts contributed by US Steel and Bear Coal Co. The Colorado Energy Research Institute made a grant to the laboratory, seeing that the control of respirable coal dust may play an important role in the development of coal as a fundamental energy resource. Public Service Co. of Colorado also made a gift to assist in purchasing equipment.

In September 1975, the authors received the first of two years' support from NIOSH, a branch of the Department of

Health, Education and Welfare. This grant will provide the basic minimum requirements of equipment and graduate support required for the establishment of the laboratory. The title of the research program is "Condensation and Nucleation Properties of Respirable Coal Dust." At the present, the authors' efforts, as well as the efforts of four graduate research assistants, are dedicated to studying these particular microscopic properties of respirable coal dust with the expectation that some significant inroads may be made that will benefit dust-control technology and the coal mining industry.

Evidence based on medical and physical research performed in Europe and the US indicates that coal workers' pneumoconiosis (black lung) can be attributed to inhaled

(and retained) coal dust in the size range of approximately 0.1 micron to 2 to 3 microns. In this size range, current technology in common use (mostly water sprays) falls to almost zero efficiency. Other conclusions are that:

- It is probably not feasible to consider serious alterations of water spray control methods.

- The dust itself should be modified to make it subject to present control methods; in particular, grow the water droplets directly on the coal dust particles, thereby making them, in effect, much larger.

- Once the particles are enlarged (say to 10 to 20 microns), they become much more easily controllable; in fact, once the particles become as large as several microns, their entry into and retention by the respiratory system is significantly impaired.

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A NEW METHOD FOR DUST SEPARATION USING AUTOGENOUS ELECTRICALLY CHARGED FOG

A NEW METHOD FOR DUST SEPARATION USING AUTOGENOUS ELECTRICALLY CHARGED FOG

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A new method for collection of dust in connection with dust separation has been developed at The Division of Mineral Processing at The Royal Institute of Technology in Stockholm, Sweden. This air cleaning method uses electrically charged water droplets. Charging occurs autogenously whereby the need for high voltage current is eliminated.

By squirting water of low conductivity (de-ionized water) through a supersonic nozzle, a fog of small, electrically charged droplets is created. These droplets attract dust particles, and separation is simply carried out on a grounded mesh net.

Droplet charges comparable to those created by high voltage have been recorded in a simple pilot plant, where an exceptionally high degree of mineral dust separation has been achieved. Further research with the new dust separation method is now in progress in a new pilot plant at The Division of Building Materials at the same Institute in Stockholm.

A NEW METHOD FOR DUST SEPARATION

This new method of air cleaning is based upon the already known techniques of binding dust particles in polluted air by means of charged droplets of water. What makes this method novel are the methods whereby droplets are charged and dust particles are separated.

The method is at first hand intended for binding breathable dust which is left in the air, after the separation of coarse dust particles has been carried out. This coarse dust separation can easily be done, e.g. by means of gravity in a cyclone. The method was primarily intended for binding mineral dust, but it should also be of possible use for smoke cleaning.

Particles belonging to the category of breathable dust, i.e. particles inhaled and carried through the human respiratory ways down to the lungs, are of a size less than 5 μm . Mineral dust includes particles down to the size of about 0.5 μm .

It is generally estimated that all particles in the μm sizes are more or less electrically charged. Since they are charged with the same polarity to a considerable extent, the repelling powers help them to remain in the air, as aerosols. Mineral dust is generally charged with the negative polarity.

Somewhat simplified, it could be stated that to catch these small charged particles, the following conditions must be provided:

1. Small water droplets must be of sizes close to those of the particles.
2. The droplets must be charged and have opposite electrical polarity to that of the particles.
3. Particles and droplets are to be given possibilities to attract each other.
4. Both droplets and particles are to be separated from the air stream.

It is nowadays technically possible to produce water droplets which are 10 μm and smaller by means such as high pressure and supersonic nozzles. The small droplets—water fog—which are generated in the nozzle, get their electrical charges autogenously according to the new method. The charge is generated in the nozzle through friction of water against the metal walls of the nozzle. This is only possible if the water is an insulator and the nozzle is grounded. To make the water an insulator, it must have a low specific conductivity, which is achieved by deionization. Thus the water fog obtains a strong positive charge.

The particle-mingled air passes through a shielded room, where the air stream meets the charged water fog, and where intimate mixing of particles and droplets takes place. Thereby particles and droplets of opposite polarity attract each other.

The electrically charged droplets have such powerful charge, that some charge is left even after particle attraction. An earthed mesh or some similar device will then act as a separator when placed in the air stream after the intermixing with the water fog. Thus the air stream emerging from the separator is dry and free from airborne particles.

BACKGROUND

For more than 40 years the mineral-based industry has fought the problem of dust, especially within the branches of industry where silicosis problems have been pronounced. In view of this The Division of Mineral Processing, The Royal Institute of Technology, Stockholm has for many years carried out research on primary dust formation from the process of crushing minerals, as well as the characteristics and behaviour of mineral particles. Especially the investigation of the reactive disposition of quartz particles carried out at The Division of Mineral Processing has increased the insight into the origin of silicosis.

For a considerable length of time research has also been carried out with the intention of improving mineral dust separators. Many attempts have been made to use water to bind dust particles. At The Division of Mineral

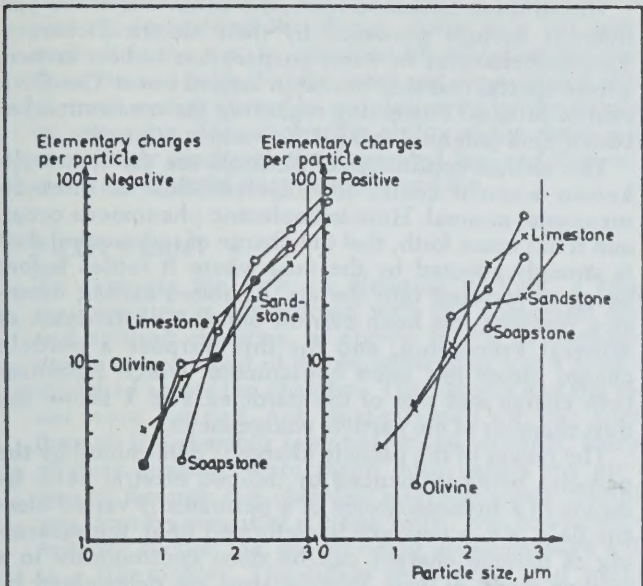


Fig. 3. Elementary charges per particle for different minerals crushed in a jaw crusher.

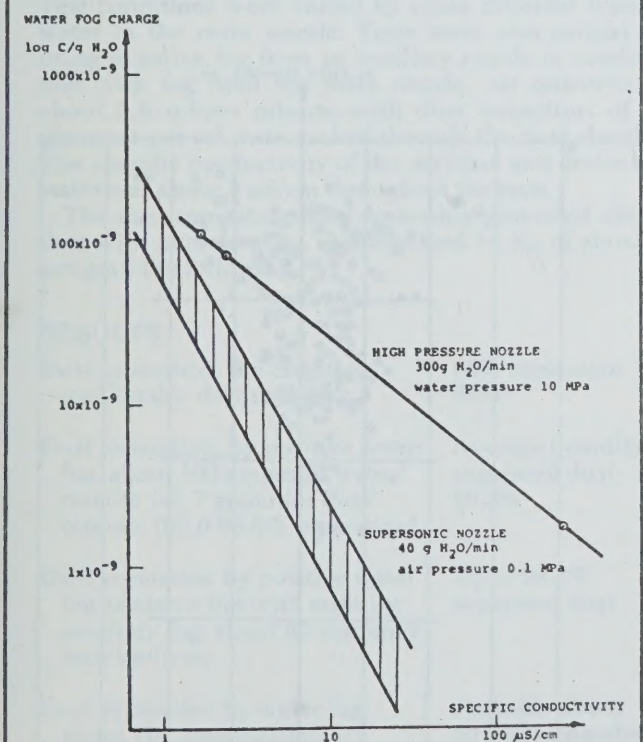


Fig. 4. Influence of specific conductivity of water on water-fog charge generated in supersonic nozzle and high pressure nozzle.

in Fig. 2, where one can see that negative charges dominate among the smaller particles below 3 μm . Fig. 3 shows how the power of charge is dependent on particle sizes.

According to the investigations, it seems that the average charge strength for 1 μm sized particles is about 5 elementary charges per particle which is equivalent of about 3.10^{-7} coulomb per gramme dust (C/g).

DROPLETS AND DROPLET CHARGES

The nozzles which were most extensively investigated were a high pressure nozzle with a revolving lining, and a pneumatic supersonic nozzle. The high pressure nozzle works with water pressure of about 10-15 MPa, and the supersonic nozzle with a water pressure of 0.1-0.2 MPa and an air pressure of 0.3-0.6 MPa.

Manufacturers of these spraying nozzles state that the high pressure nozzle produces droplets of sizes down to 30 μm , while the droplets produced by the supersonic nozzles have a maximum size of 1-5 μm of a smaller, and 5-15 μm of a larger size of nozzle. In connection with these droplet sizes, it could be mentioned that the meteorologists label droplets of 20 μm size and smaller as dry, non-wetting fog. Fog is wetting however, when consisting of droplets ranging in sizes from 20-100 μm . Dry fog is defined by its properties of not adhering to objects in its way.

The electric dust separator which is being used today is an electric filter where gas ions are charged from a high voltage apparatus. Charging of water droplets, based upon electric high voltage is a method which is being developed. The voltage feed in the latter method has a range of 5-10 kV.

The new method is based on the principle of creating electrically charged water fogs without using a high voltage apparatus. Through studies of behaviour and characteristics of water droplets generated in the nozzles, it came out at different electrolytic content that water of low specific conductivity in the nozzles, resulted in a powerfully charged fog of positive polarity. A low conducting ability can be achieved by distilling, and above all by deionizing the water. A water fog with negative polarity was experimentally produced by adding certain cation active tenside to ordinary tap water. In comparison, the effect of negative charge was weaker than the positive. The tenside quantity was about 1 ppm. Only limited attempts to generate fog of negative charge were made.

The generating of positively charged water fog is of friction-electrical nature. A material of low conductivity and high dielectric constant, (the de-ionized water) is intensely rubbed against a metallic body (the channel walls of the narrow nozzle). Both types of nozzles give, although in different ways, more powerful charge when the water is of low specific conductivity (Fig. 4.)

The charge was optimized to about 15×10^{-7} coulomb per gramme water at the water specific conductivity of 0.6 $\mu\text{S/cm}$ ($\text{S} = \text{siemens}$). Ordinary tap water was found to have the specific conductivity of 300 $\mu\text{S/cm}$. The most favourable results were achieved when using supersonic nozzles, which is evident from Fig. 5. Differently modified nozzles have been tested, and it is interesting to note, that when using water channels of a more inert metallic material in the nozzle, it seems that a better electron transfer takes place from the water to the nozzle. For example, goldplating of one specific nozzle resulted in increased charging capacity, as shown in Fig. 6.

A comparison of the power between particles charges and droplets charges of the water fog shows that 0.2 gramme of water from the positive fog should discharge about 1 gramme dust. On the other hand, to discharge

Processing, studies have been made on the possibilities of binding and separating mineral dust from air suspensions by means of water precipitation, in which case the dust particles acted as condensation nuclei. Attempts were also made to charge water droplets by applying a voltage to the water supply.

However, it was not until 1974 that the idea of charging the water droplets electrically by means of friction originated. It seemed to be a sensible way to bind airborne mineral particles by making use of their electrical charges.

PARTICLE CHARGES

The fine dust particles, which have predominantly been the object of research carried out by The Division of Mineral Processing, emerge from the three-dimensional mineral which has gone through some form of crushing or abrasive wear, thereby producing dust of particle sizes of about 0.5-10 μm . Particles smaller than 0.5 μm are seldom found as crushed products of three-dimensional minerals. On the other hand, dust of two-dimensional minerals has sizes smaller than 0.5 μm as, for example, nature's own breakdown product clay, as well as dust of a soot-like character, deposited and accumulated from industry. Particles larger than about 10 μm sediment easily, and do not constitute major difficulties in dust separation.

Within these indicated sizes, the behaviour of the particles is strongly governed by their electrical charges. Particle behaviour in water suspensions is best known, where special research has been carried out at The Division of Mineral Processing regarding the connection between Zeta-potential and pH for various minerals.

The charge conditions of aerosols are far less well-known when it comes to dispersed dust of three-dimensional mineral. Here triboelectric phenomena occur, and it has come forth, that the charge of sedimented dust is strongly affected by the area where it settles before being re-vortexed into the air. As stated earlier, extensive research has been carried out at The Division of Mineral Processing, and for this purpose a particle charge meter has been constructed, which measures both charge and size of the particles. Fig. 1 shows the dust chamber of the particle charge meter.

The power of the particle charge is determined by the particles being influenced by defined electric field. By means of a suitable choice of a periodically varied electric field, e.g. a sawtooth waveformed field, the measuring of particle charges can be done continuously in a settling cloud of dust. Particle sizes are determined by measuring the velocity of fall in accordance with Stokes's law. The movement and the speed of the particles are registered photographically.

Particle charges for quartz dust particles, obtained from an air suspension directly after crushing, are shown

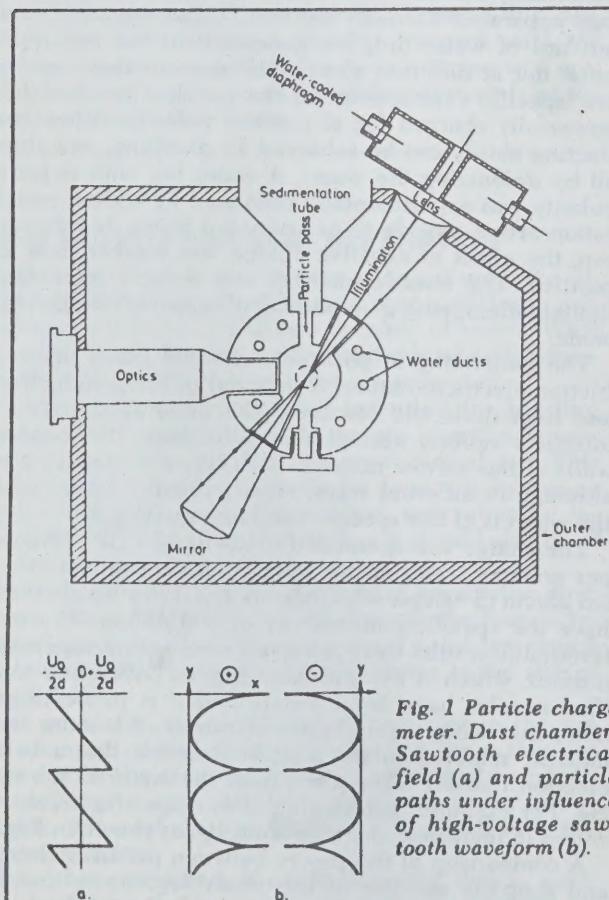


Fig. 1 Particle charge meter. Dust chamber. Sawtooth electrical field (a) and particle paths under influence of high-voltage sawtooth waveform (b).

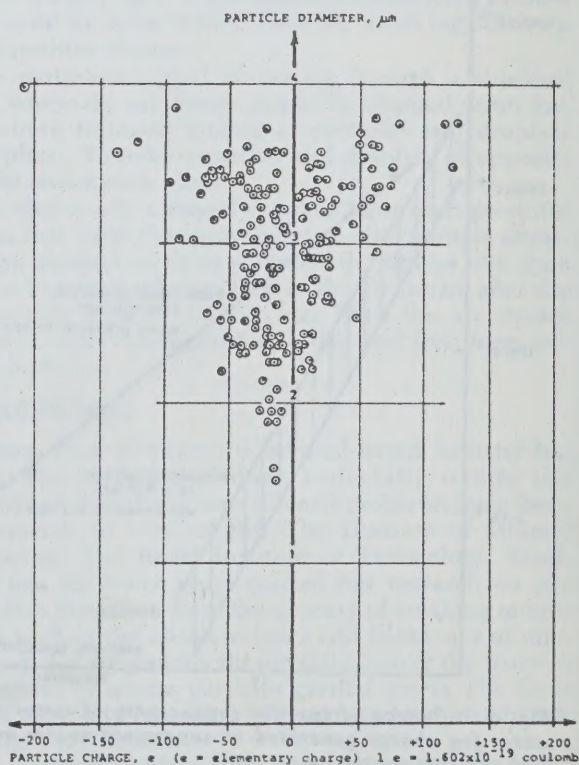


Fig. 2. Dust particle charges. Quartz dust from disc crusher.

one gramme of dust with the negatively charged fog mentioned earlier, 300 grammes of water would be needed.

The potential of the generated water fog was measured on a metal mesh by means of an electrometer, as shown in Fig. 7. The measuring equipment shown here is arranged for testing water fog from a supersonic nozzle. By connecting the charge meter to a net and by grounding the nozzle, and then by reversing the procedure, it came forth that the mesh net accumulated almost as much excess charge as was delivered by the nozzle to its water fog. This shows the ability of the mesh net to completely discharge the generated fog, and thus to remove the charged dust particles and fog.

PILOT PLANT

To evaluate the new air cleaning method, a simple equipment was constructed with the combined spray- and settling chamber, as shown in Fig 8. Supersonic nozzles were a part of the equipment, as was a mesh net stretched across the chamber. The nozzles and the mesh net were earthed, and dust-mingled air was sucked through the chamber from below and upwards. Samples of dust quantity were taken both before the air had passed through the chamber and afterwards. Sampling was done by means of a probe which was connected to a separate suction fan, the air being drawn through a filter in a filterholder. The filters were dried and weighed before and after sampling. Some tests were carried out with a negatively charged fog as an auxiliary fog in accordance with Fig. 8.

DUST SEPARATION TESTS

Different tests have been carried out in the simple dust separating plant, both with olivine dust and quartz dust. Test conditions were varied by using different types of water in the main nozzle. Tests were also carried out using negative fog from an auxiliary nozzle in combination with fog from the main nozzle. Air quantities of about 5.6 m³/per minute with dust quantities of 1-2 grammes per m³ were sucked through the dust chamber. The specific conductivity of the distilled and de-ionized water was about 1 µS/cm throughout the tests.

The dust separation tests on freshly grounded olivine dust with particle sizes characterized by k_{80} of about 30 µm gave the following

RESULTS

Dust separation, the chamber used as dry dust separator	68% separation dust
Dust separation, by positive water fog, about 100 grammes water/minute per 7 grammes dust/minute. (98.0-98.6% separation)	Average quantity of separated dust 98.3%
Dust separation by positive water fog as above but with negative auxiliary fog, about 50 grammes water/minute	Up to 98.8% separated dust
Dust separation by water fog, about 100 grammes/minute generated from ordinary tap water. (86.1-96.3% according to measured results)	Probably about 80-90% separated dust

Measurements of dust separation when ordinary tap water was used were rendered difficult because the fog generated was not charged. It passed the mesh net with-

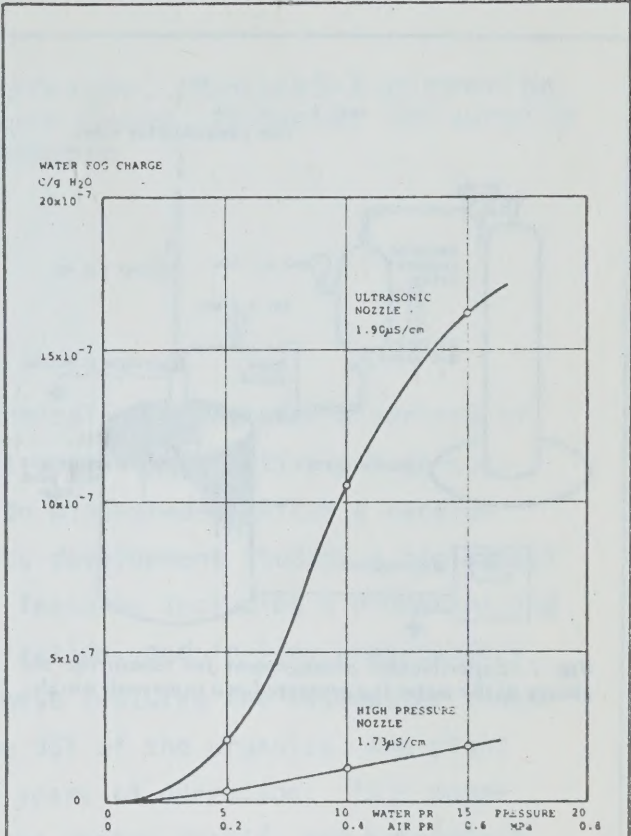


Fig. 5. Influence of water pressure and air pressure respectively on water fog charge generated in supersonic nozzle and high pressure nozzle.

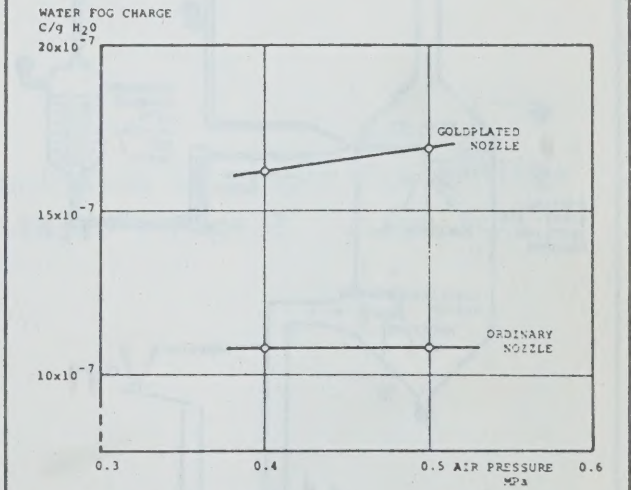


Fig. 6. Water fog charge generated in a goldplated supersonic nozzle and an ordinary one of the same sort at a constant water flow of 25 g/min. Specific conductivity of the water 0.6 µS/cm.

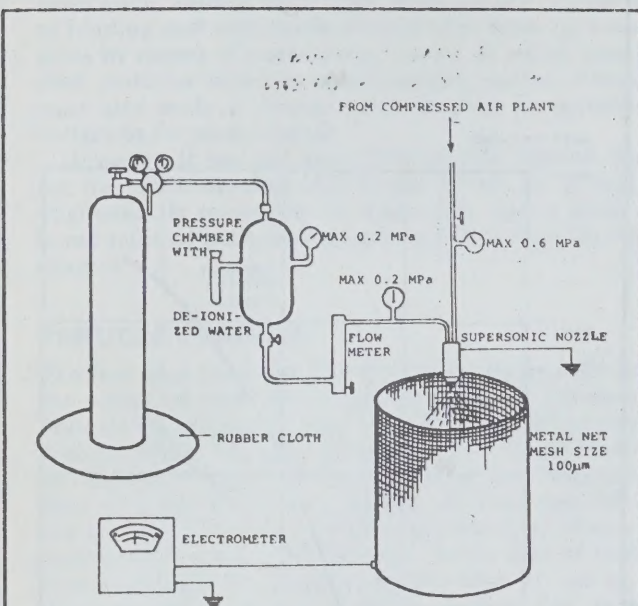


Fig. 7. Experimental arrangement for measuring the charge of the water fog generated in a supersonic nozzle.

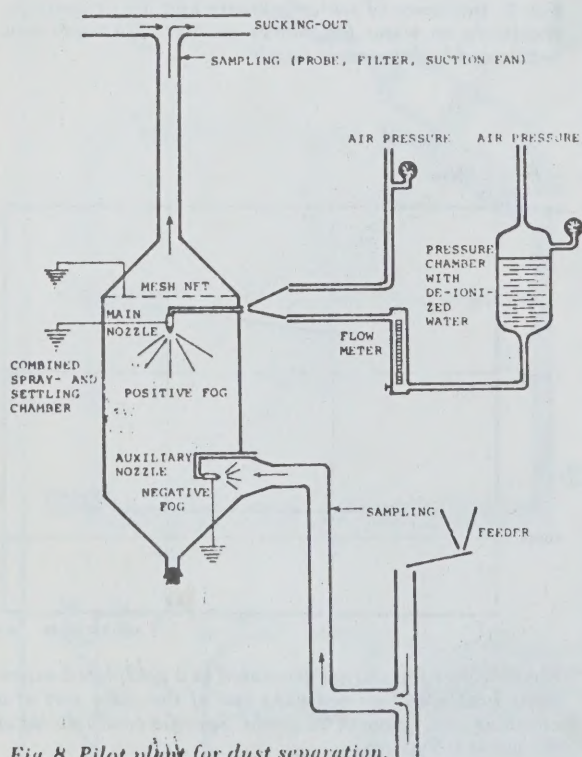


Fig. 8. Pilot plant for dust separation.

out depositing thereby moistening the walls of the probe in the upper part of the plant. Some dust particles thus adhered to the walls of the probe thereby reducing the quantity of dust collected by the filter.

Dust separation tests on aged quartz dust of k_{80} about 35 µm gave the following results:

Dust separation, the chamber used as dry dust separator	About 36% separated dust
Dust separation by positive water fog alone, in the main nozzle. About 100 grammes water/minute	About 80% separated dust
Dust separation by negative water fog alone, in the auxiliary nozzle. About 50 grammes/minute.	About 65% separated dust
Dust separation by positive and negative water fogs combined. About 100 grammes water/minute and about 50 grammes water/minute respectively.	About 96% separated dust

Tests were also carried out with ordinary tap water in the main nozzle together with the negative water fog generated in the auxiliary nozzle. This gave a surprisingly good result, although readings were of considerable uncertainty. The degree of separation was probably around 90%.

As can be seen, the quartz dust, that was used, (wet grounded, dried and stored) turned out to be considerably more difficult to moisten in comparison with the freshly ground olivine dust.

The tests can be regarded as a kind of pilot studies and were consequently designed to act as guides to further, more complete investigations approaching optimal circumstances. They were also done under shortage of time and with qualities of dust which were, due to ageing, not quite adequate.

The results show, however, that the method has excellent separating efficiency, especially when considering that separation concerns particles of such small fractions which are generally regarded as being very difficult to separate. Autogenous generation of highly charged water fog as well as the separation concerns particles and the fog were successfully achieved.

ACKNOWLEDGEMENTS

The development of the new dust binding method together with the dust binding research has been sponsored primarily by The Swedish Mining Association-Mining Research, The Swedish Water and Air Pollution Research Institute and The Swedish Board for Technical Development. Hans Bjelkesjö, Master of Mining Engineering, has been my foremost co-worker.

Further investigations with the new dust separation method is now taking place at The Division of Building Materials at the same Institute in Stockholm, and still with Hans Bjelkesjö as co-worker. The Swedish Board for Technical Development has contributed economically to the building of a new and more appropriate equipment with possibilities of testing dust binding under adequately controlled circumstances and to the acquisition of representative qualities of dust. It is hoped that the new equipment can be used for studies of purification of smoke.

THE PROCESS DESIGN AND EVENTUAL OPERATION OF A WASTEWATER
TREATMENT PLANT FOR A DETERGENT MANUFACTURING COMPLEX

by

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Hamilton, Ontario

The Longford Mills plant of Domtar Chemicals manufactures a variety of detergents. The wastewaters from this plant contain a relatively high concentration of organics that are difficult to biodegrade. After a careful period of in-plant modification, and process development studies a biological treatment system was built with many novel features including a proper mixing of different organics, aeration tank equilization, and in-line presecondary clarifier alum addition. As a result of these features the wastewater treatment plant consistently removes better than 95% of the organics, and plant up-sets have been avoided over the last two years of operation. This paper reviews the steps leading up to designing, the design itself, and subsequent operation of the treatment plant.

Note: Paper arrived too late for inclusion in proper Proceedings sequence. See "Supplementary Paper", Page 2 , for full text.

**SESSION V
CHAIRMAN**



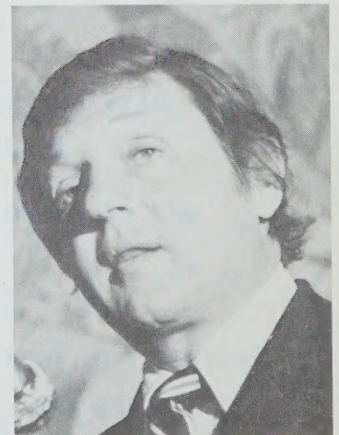
G. W. Scott, Q.C.

Deputy Minister
Ontario Ministry of the Environment

THE MISSISSAUGA INCIDENT – ACTIONS, PROBLEMS AND EXPECTATIONS



T. W. Cross
Director,
Air Resources Branch
Environment Ontario, Toronto



The Honourable R. R. McMurtry, Q.C.
Solicitor General
Province of Ontario



Her Worship Hazel McCallion
Mayor
City of Mississauga

MISSISSAUGA TRAIN DERAILMENT - OPERATIONAL OVERVIEW -
FROM THE AIR VIEWPOINT - T.W. CROSS, DIRECTOR AIR
RESOURCES BRANCH, ONTARIO MINISTRY OF ENVIRONMENT

On November 10th, a train derailment in Mississauga gave a lot of people an opportunity to prove that old adage - "When the going gets tough, the tough get going". Firemen, policemen, politicians, railway crews, Red Cross workers, chemical company employees and Ontario Government employees demonstrated a toughness that I personally have not experienced since World War II. For 9 days these people worked long hours with a common purpose and showed a selflessness that we do not see very often in our society today. For all 9 days at least, the large number of people involved became the "WE" GENERATION.

This paper will address itself to the operations of the Air Resources Branch of the Ministry of the Environment, but we ask you not to lose sight of the other branches whose operations will be recorded elsewhere. Briefly, they include:

- The people from the Central Region who were first on the scene and the last to leave
- Contingency Planning staff of the Pollution Control Branch who were involved on the site and since in absorbing the lessons learned
- The Laboratory Services Branch who sampled and analyzed the flow of water around the site for contaminants
- The head office people who covered for those of us in the field for that long week

In addition, the Ministry of Labour provided field crews and medical advice throughout the whole period. The Atmospheric Environment Service of Environment Canada provided stepped-up meteorological forecasting and minisonde crews who kept our site team well supplied with very essential data on windspeed and direction. In addition, we stole a lot of their balloons to tether at the derailment site to give firemen a continual visual check on wind direction to ensure the best deployment of fog nozzles.

DESCRIPTION OF THE PROBLEM:

There was so much written locally on this derailment and so much interest in it and the evacuation that it should be only necessary to give a brief description of the event. A train composed of a large number of freight and tank-cars suffered a partial derailment of 23 tank-cars. These cars contained chlorine, propane, toluene, styrene and caustic soda. After 2 violent explosions of hydrocarbon tank-cars, one of which landed half a mile away and one which opened up like an exploded sausage roll, the main problems were a large fire and chlorine leaking from a damaged chlorine car in the middle of the pile up.

Much has been written on the "fortunate" aspects of this derailment and I think some of them bear repeating:

FORTUNATE ASPECTS OF THE DERAILMENT:

The accident happened in one of the few locations that:

- a) was not immediately adjacent to residential areas
- b) had good road access for the heavy vehicles required
- c) had a good command site very close, with lots of communication equipment
- d) had sufficient open space for one hydrocarbon tank-car to fly through the air for half a mile and still land in an open field
- e) had a large water main available
- f) had large urban areas immediately adjacent to absorb the evacuated population
- g) and last, but not least, the Region had an evacuation plan.

Perhaps the most fortunate aspect of the event was the explosion that damaged the chlorine tank originally. As near as we can construct,

this explosion, which sent a huge fireball several thousand feet upwards, apparently aspirated approx. 70 tons of the 90 tons of chlorine in the damaged tank-car. If the tank had been completely ruptured and if the explosions had dispersed this chlorine horizontally, the disaster potential was extremely high.

FIRST INSPECTION OF CHLORINE CAR:

On the afternoon of the second day the Dow Chlorex (Chlorine Episode) crew inspected the chlorine tank-car while the fires were still in progress. They found a 3 foot hole on the shell of the tank-car which unfortunately included some damage to the dished head of the car making patching difficult.

Visual inspection, using a dipstick inside the car, revealed approx. 20 tons of chlorine remaining, covered with approx. 9-12 inches of ice or a similar substance.

The defusing of the derailment was broken down into the following steps:

1. Permit the fires in the ruptured hydrocarbon tanks to burn out while keeping the other cars in the pile-up cool, so that they would not rupture
2. Stabilize the chlorine tank by patching the leak, the extent of which was not known during the first two days
3. Remove the liquid and gaseous chlorine from the damaged tank-car
4. Clean up the site

NITTY GRITTY POINTS:

During this event there were several moments of truth or "Nitty-Gritty" points. These included, of course, the derailment and initial explosions. As the episode proceeded, they included:

- the potential for other explosions and the possibility of increased releases of chlorine.
- leaks during removal of the chlorine liquid and vapour from accidents and disconnecting of tank-cars, etc.
- the possible role of the "ice" blanket as the chlorine was removed and the ice blanket collapsed into the remaining liquid.

AIR RESOURCES BRANCH ROLE:

The Air Resources Branch role in this was as follows:-

Air Monitoring:

A decision was made early on Sunday morning that only "real-time" monitoring would be of any use in this situation. Accordingly, a decision was made to remove our T.A.G.A. 3000 mobile air monitoring van from the St. Lawrence Cement Co. where it was being used to test its ability to monitor PCBs incorporated in the usual gases and solids in the cement plant emissions.

This involved the removal of a housing around the van, the removal of blocks under the van and the disconnecting of a glass sampling line to the stack breeching. In addition, we approached the developer and builder of the T.A.G.A. - Sciex Inc. - to see if they could lease us a second unit and provide staff to operate the 2 units. Again fortune reared its smiling face as Sciex's T.A.G.A. 2000 had just returned from the U.S. and it was calibrated for chlorine which they had been monitoring at a U.S. spill.

Because our T.A.G.A. 3000 was calibrated for PCBs and there were mistaken rumours of PCBs being involved in the derailment, we did sampling for PCBs for the first two hours. When none was measured, the T.A.G.A. 3000 was cross-calibrated with the T.A.G.A. 2000 for chlorine and from then on that was 90% of our monitoring efforts.

Subsequently, both T.A.G.As. were calibrated against known mixes of chlorine.

Periodically, the T.A.G.As. were used for "scans" to note the excess presence of other chemicals in the air. The only other contaminant of any significance during this period was chloro-aceto-phenone - a lacrimator formed by the combination of styrene, chlorine and ozone. The styrene was spread all around the site from leaking tank-cars.

The use of the two T.A.G.As. running across the plume at various distances enabled us to plot the plume location and its degradation. This was very useful in determining any levels which might occur outside of the evacuated area. Generally speaking, the concentrations of chlorine were below 400 micrograms or 0.13 ppm. There were 2 brief periods when levels were between 400 and 1000 micrograms, The T.A.G.As. were non-linear in response above 400 micrograms and if these higher levels had persisted, the T.A.G.As. would have been recalibrated.

Criteria:

The following criteria was used for evaluating chlorine levels in the ambient air:

Normal background	-	less than 0.001 p.p.m. or 3 micrograms
Discomfort level	-	0.01 " " 30 "
Acceptable workplace exposure (8 hours)	1.0	" " 3000 "
Health threat threshold level (15 minutes)	3.0	" " 9000 "
Acute danger to human life	900	"

Meteorological Monitoring:

The Air Resources Branch maintains its own staff of meteorologists and we also maintain a close, long standing relationship with the Atmospheric Environmental Service - Environment Canada. To develop

the best micro-meteorological input into the decision making of the Command Executive we laid on the following:

1. An Air Resources Branch meteorologist and an additional Atmospheric Environmental Service meteorologist were added to the usual staff at Toronto International Airport
2. The Atmospheric Environmental Service supplied us with a minisonde crew at the Command site. They released balloons with small disposable radio equipment and tracked their path downwind to enable us to predict plume paths as accurately as possible
3. The Air Resources Branch Mobile Air Monitoring Unit #2 was based near the Command Post to give us continuous windspeed and direction at the 10 metre level and to provide a communications centre for the mobile units downwind.

Ministry of the Environment Reports:

The Ministry of the Environment and its contractor, Sciex Inc., have produced 6 reports covering ambient air monitoring, meteorology summary, water monitoring and vegetation damage covering the derailment period and afterwards. While these are not available for "best seller" distribution, they have been supplied to the parties involved in the clean up of the derailment and can be provided to people with an obvious interest in the matter.

Air Mass Modelling:

Air mass modellers were based at 880 Bay Street and, periodically, at the site to produce predictions of probable concentrations of chlorine at various distances downwind under several scenarios of chlorine releases from the site. These calculations, together with those of Dow Chemical and health criteria were used in determining the area to be evacuated if a large instantaneous release took place. Close

agreement between the two sets of modellers indicated a potential for human suffering, including death over a considerable distance depending on meteorological conditions.

Chlorine monitoring provided an opportunity of back modelling to estimate size of releases for practical checks against what was happening.

Technical Advice to the Executive Command Group:

The above monitoring, air mass modelling and meteorology, was used to help the Executive Command under the Attorney General to reach decisions on evacuation and repopulation. This, together with medical advice from the Ministry of Labour and technical advice from the Chlorex crew from Dow Chemical was presented to Mr. McMurtry's committee regularly and on demand.

Air sweeps were performed in areas under consideration for repopulation before the people were let back in, with particular attention being paid to low lying areas whenever possible.

The operation of the Dow Chlorex crew was placed under the supervision of the Ministry of the Environment to ensure that meteorology and environmental safety were always taken into consideration in the removal of the chlorine from the tank-car.

Hindsight:

Our impressions are of a job well done by a lot of tough minded people. Dedication and co-operation were the order of the 9 days. As residents of Mississauga, we were pleased with the results, including the fact that our homes were intact when we got back into them. There are many communities in North America where this would not be the case. Telephone calls from all over N. America and from as far away as Japan, Belgium and other European countries expressed amazement at the large number of people evacuated and the lack of looting. Some

of this was the result of planning, such as the Peel Regional Police evacuation plan. A lot of it was the result of good "ad hoc" command and operations. Hindsight indicates the need for cut and dried planning and training with every agency knowing what to expect from the other. From subsequent spills of vinyl chloride in Manitoba and the derailment last week at London, this planning should take place immediately as it looks like railroad spills of hazardous contaminants will be with us for some time. The Ministry of the Environment is doing its share of this planning and will contribute to an overall Ontario contingency plan.

THE HONOURABLE R. ROY MCMURTRY

ATTORNEY GENERAL

SOLICITOR GENERAL

PROVINCE OF ONTARIO

RE

MISSISSAUGA INCIDENT

MR. CHAIRMAN, ITS A PLEASURE TO BE HERE, EVEN AT THIS EARLY HOUR IN THE DAY ON THE MORNING AFTER YOUR MAIN BANQUET AND DANCE.

THE TITLE OF THIS SESSION IS THE MISSISSAUGA INCIDENT - - ACTIONS, PROBLEMS AND EXPECTATIONS. I WILL TOUCH ON ALL THREE AS THERE WAS PLENTY OF ACTION AND NUMEROUS PROBLEMS. AND SINCE THAT HECTIC WEEK LAST NOVEMBER THERE HAS BEEN AN ALTERING OF EXPECTATIONS.

NO DOUBT THE TOPICS WILL BE COVERED FROM A DIFFERENT VIEWPOINT LATER IN THIS SESSION BY TOM CROSS AND MAYOR MCCALLION WHO BOTH PLAYED CRUCIAL ROLES IN WHAT HAS BEEN DESCRIBED AS THE LARGEST EVACUATION IN NORTH AMERICA.

BRIEFLY, AND BY WAY OF BACKGROUND, LET ME SKETCH IN THE EVENTS OF WHAT HAS BEEN APTLY DESCRIBED AS THE MIRACLE OF MISSISSAUGA.

AT 10 MINUTES TO MIDNIGHT ON NOVEMBER 10, THE REAR WHEELS ON ONE TANK CAR FLEW OFF. A FEW MOMENTS AND 2.8 KILOMETERS LATER, THE TRAIN DERAILED AT THE MAVIS ROAD CROSSING. TWENTY-TWO TANK CARS AND TWO BOX CARS LEFT THE TRACKS.

THE TANK CARS WERE LOADED AS FOLLOWS: ELEVEN WITH PROPANE, THREE WITH STYRENE, ONE WITH CHLORINE, FOUR WITH CAUSTIC SODA AND THREE WITH TOLUENE.

SEVERAL TANK CARS RUPTURED IMMEDIATELY AND SOME OF THE FLAMMABLE LIQUIDS BEGAN BURNING AT A SLOW RATE.

ONE MINUTE LATER A LARGE EXPLOSION OCCURRED AND THERE WAS ANOTHER, MORE VIOLENT BLAST AND FIRE AT 10 MINUTES AFTER MIDNIGHT. ONE PROPANE TANK BLEW TO PIECES.

ABOUT SEVEN MINUTES LATER ANOTHER EXPLOSION OCCURRED WHEN THE END OF ONE PROPANE TANK CAR BLEW OFF.

HERE IS THE DESCRIPTION OF THIS BLAST FROM A POLICE REPORT: "THE MAIN BODY OF THE CAR, STILL FILLED WITH LIQUID PROPANE, WAS PROPELLED ROCKET FASHION INTO THE AIR SPEWING ITS FIREY CONTENTS BEHIND. THIS AIRBORNE PROJECTILE CLEARED A HARDWOOD BUSH TO THE NORTHEAST AND TUMBLED ACROSS A FIELD BEFORE COMING TO REST APPROXIMATELY 2,250 FEET FROM THE MAVIS ROAD CROSSING."

THERE WERE FURTHER EXPLOSIONS DURING THE MORNING AND THE FIRES CONTINUED BURNING, UNDER CONTROLLED CONDITIONS, UNTIL 2:30 A.M. NOVEMBER 13 - - ABOUT 50 HOURS AFTER THEY STARTED.

ALMOST TWO HOURS AFTER THE DERAILMENT, WHEN IT BECAME APPARENT THAT HAZARDOUS SUBSTANCES WERE LEAKING FROM THE WRECKAGE, THE POLICE CHIEF OF PEEL REGION ORDERED THE RESIDENTIAL AREA CLOSEST TO THE SITE EVACUATED.

THE EVACUATIONS PROCEEDED IN AN ORDERLY FASHION THROUGH THE PRE-DAWN HOURS AND BY NOON, 12 HOURS AFTER THE DERAILEMENT, 71,000 PEOPLE HAD BEEN MOVED. WITHIN 24 HOURS, THE FULL AREA WAS CLEARED OF CLOSE TO A QUARTER OF A MILLION PEOPLE.

THE RESIDENTS WERE RETURNED IN STAGES AS THE DANGER LESSENER. THE FIRST RETURNED IN THE AFTERNOON OF NOVEMBER 13 AND ALL EXCEPT A FEW VERY CLOSE TO THE SITE WERE BACK IN THEIR OWN HOMES BY THE NIGHT OF NOVEMBER 16.

NOW, WITH THAT BACKGROUND, LET ME TURN TO THE "ACTIONS" PORTION OF THE SUBJECT MATTER FOR DISCUSSION HERE.

AS I INDICATED, THE INITIAL EVACUATION WAS ORDERED BY THE POLICE ACTING, PROPERLY IN MY VIEW, TO GUARD PUBLIC SAFETY.

THE SUBSEQUENT EVACUATIONS WERE THE RESULT OF EXTENSIVE CONSULTATIONS WITH EVERY AVAILABLE EXPERT AND OFFICIAL, AS WERE THE DECISIONS PERMITTING RESIDENTS TO RETURN.

MY ROLE AT MISSISSAUGA WAS THAT OF A CO-ORDINATOR, THE CHAIRMAN OF THE MEETINGS AT WHICH THE SITUATION WAS ANALYZED AND VARIOUS ACTIONS TAKEN AS A RESULT.

IN THE FIRST HOURS OF THE EMERGENCY, THESE MEETINGS WERE HELD SEVERAL TIMES DAILY AND RELATIVELY INFORMALLY, USUALLY IN THE POLICE COMMAND TRAILER.

AFTER THE FIRST COUPLE OF DAYS WHEN THE FIRES HAD BURNED THEMSELVES OUT UNDER CONTROLLED CONDITIONS AND IT WAS POSSIBLE FOR THE FIRST TIME TO CONSIDER REDUCING THE AREA OF THE EVACUATION, THESE MEETINGS WERE MOVED INTO A BOARDROOM IN A BELL CANADA BUILDING NEAR THE SITE.

WE TOOK THE EXCEPTIONAL AND EXTRAORDINARY STEP OF RECORDING THE PROCEEDINGS OF THESE MEETINGS SO THAT THERE WOULD BE A PERMANENT AND RELIABLE RECORD AVAILABLE IN RESPECT OF THE DECISION-MAKING PROCESS.

TRANSCRIPTS OF THESE MEETINGS HAVE BEEN FILED AS EXHIBITS AT THE FEDERAL INQUIRY NOW UNDERWAY INTO THE CAUSE OF THE DERAILMENT.

THE TRANSCRIPTS REVEAL THAT THERE WERE A SERIES OF DECISIONS TO DETERMINE WHEN IT WAS SAFE FOR RESIDENTS IN THE DIFFERENT SECTORS TO RETURN HOME.

WITHOUT EXCEPTION THEY DEMONSTRATE THAT EVERY ONE OF THESE DECISIONS WAS MADE AFTER CANVASSING THE THOUGHTFUL ADVICE OF THE GOVERNMENT, ACADEMIC AND INDUSTRY EXPERTS. NO ONE WHO HAD A USEFUL CONTRIBUTION TO MAKE WAS KNOWINGLY EXCLUDED.

WITHOUT EXCEPTION, EVERY ONE OF OUR DECISIONS HAD THE UNANIMOUS SUPPORT OF EVERYONE IN THE ROOM, INCLUDING A VICE-PRESIDENT OF CP RAIL.

THE TRANSCRIPTS FURTHER SHOW THAT PUBLIC SAFETY WAS THE PRIMARY CONSIDERATION, THAT LIVES AND HEALTH TOOK PRECEDENCE OVER ANY OTHER CONSIDERATIONS.

LET THERE BE NO DOUBT ABOUT THE FACT THAT THOSE MEETINGS WERE OFTEN TENSE. THE STAKES WERE ENORMOUS. WE WERE MAKING DECISIONS THAT COULD IMMEDIATELY EFFECT THE HEALTH, AND EVEN THE LIVES, OF A QUARTER OF A MILLION PEOPLE.

IN THE COURSE OF THE FEDERAL INQUIRY, EFFORTS HAVE BEEN MADE TO DISCREDIT THIS PROCESS AND THE DECISIONS TAKEN.

BUT I WANT TO STRESS TO YOU AND TO THE PEOPLE OF MISSISSAUGA THAT I AM SATISFIED THAT WE HAD THE BEST ADVICE AVAILABLE, THAT WE EXPLORED EVERY ISSUE THOROUGHLY AND THAT WE TOOK THE PROPER AND PRUDENT COURSE.

I AM CONFIDENT THAT ANY IMPARTIAL EXAMINATION OF THE EVENTS OF LAST NOVEMBER SHOW PRECISELY THOSE FACTS.

AS SOME PEOPLE SEEM BENT ON RE-WRITING HISTORY OF THOSE MEETINGS FOR THEIR OWN PURPOSES, LET ME READ YOU A SHORT PORTION OF THE FINAL MEETING ON SUNDAY, NOVEMBER 18.

I HAD JUST THANKED THOSE PRESENT WHO INCLUDED R.S. ALLISON, VICE-PRESIDENT OF CP, AND JOHN MCGEE OF THE CANADIAN TRANSPORT COMMISSION, WHEN MR. ALLISON SPOKE. HERE'S HOW IT WAS RECORDED:

MR. ALLISON: MR. MINISTER, MADAM MAYOR AND GENTLEMEN, WE'VE ALL HAD A VERY DIFFICULT WEEK, AND ON BEHALF OF CANADIAN PACIFIC, I WOULD LIKE TO EXPRESS OUR APPRECIATION FOR ALL THE HELP AND ASSISTANCE THAT WE'VE RECEIVED.

MR. MCMURTRY: THANK YOU, MR. ALLISON.

MR. MCGEE: WITHOUT SPEAKING TO TODAY, MR. MINISTER, AND ALTHOUGH I'M NOT OF THE HIGHEST ESTATE IN THE FEDERAL HIERARCHY, I SEEM TO BE THE SENIOR FED HERE THIS MORNING. AND I WANT TO CONGRATULATE YOU AND TO EXPRESS TO YOU AND THE MAYOR MY ADMIRATION FOR THE WAY THIS THING HAS BEEN HANDLED AT THE PROVINCIAL AND MUNICIPAL, AND THEIR JURISDICTIONS, AND I THINK IT'S THE REASON THAT WE'RE SITTING HERE NOW WITHOUT A SINGLE LOSS OF LIFE.

MR. MCMURTRY: THANK YOU VERY MUCH, MR. MCGEE.

I RECITE THAT SECTION, MR. CHAIRMAN, TO ILLUSTRATE THE SPIRIT OF CO-OPERATION AND UNANIMITY IN DECISION-MAKING THAT PREVAILED. IT WAS NOT AT ALL LIKE SOME WOULD HAVE THE PUBLIC BELIEVE NOW SEVEN MONTHS LATER.

IT IS WORTH NOTING THAT 92 PER CENT OF THE EVACUEES SURVEYED SHORTLY AFTER RETURNING TO THEIR HOMES FELT THE EVACUATION WAS JUSTIFIED FOR THEIR OWN HEALTH AND SAFETY.

I WILL TURN NOW TO THE SECOND PART OF OUR SUBJECT, THE "PROBLEMS" TOO NUMEROUS TO RECOUNT HERE IN THE TIME AVAILABLE. AND I AM SURE MR. CROSS AND MAYOR MCCALLION WILL TOUCH ON SEVERAL.

I WILL DEAL WITH ONE THAT CAUSED PARTICULAR ANXIETY AT THE TIME AND HAS RAISED SOME MISUNDERSTANDING SINCE THE EVENT.

AS THOSE OF YOU WHO HAVE SEEN PHOTOGRAPHS WILL REALIZE, THE 24 RAIL CARS WHICH LEFT THE TRACKS WERE A TANGLED, TWISTED AND CHARRED MESS.

THE FIRST POLICE AND FIREFIGHTERS AT THE SCENE HAD NO WAY OF TELLING WHICH CAR CONTAINED WHICH SUBSTANCE. THE TRAIN MANIFEST WAS OF NO IMMEDIATE HELP.

WHILE IT BECAME APPARENT SOON AFTER THE DERAILEMENT THAT CHLORINE HAD ESCAPED FROM ONE CAR, WE HAD NO IDEA HOW MUCH.

THE CREWS WORKING ON THE WRECKAGE KNEW THE CAR HAD BEEN DAMAGED BUT WHILE THE FIRE RAGED AND THE RISK OF FURTHER EXPLOSIONS REMAINED HIGH THE DAMAGE COULD NOT BE PRECISELY DETERMINED.

THE FIREMEN AND CREWS FROM DOW CHEMICAL, WORKING AT EXTREME RISK, BEGAN TO DEVISE A METHOD OF PATCHING THE THE THREE-FOOT HOLE IN THE CAR.

A VARIETY OF METHODS, INCLUDING STEEL PLATES, WOOD AND INFLATABLE RUBBER, WERE USED IN THIS PATCHING WHICH NEVER WAS COMPLETELY SUCCESSFUL.

IT WAS DURING THIS PROCESS AND ONCE THE FIRES HAD BURNED OUT THAT THE CREWS DISCOVERED A SUBSTANTIAL AMOUNT OF THE CHLORINE HAD ESCAPED AT THE TIME OF THE DERAILMENT AND EXPLOSIONS.

WE MAY NEVER BE ABSOLUTELY CERTAIN ABOUT THIS BUT THE MOST RELIABLE THEORY IS THAT WHEN THE HOLE IN THE CAR WAS OPENED, THE FORCE OF THE FIRE AND EXPLOSIONS IN THE PROPANE TANK CARS SUCKED UP TONS OF CHLORINE AND DISPERSED IT HARMLESSLY HIGH IN THE ATMOSPHERE.

HOWEVER, I WANT TO STRESS THAT THERE REMAINED IN THE CAR SUFFICIENT CHLORINE, ABOUT 20 TONS, TO POSE A RISK AND IT WAS THE UNANIMOUS DECISION THAT THE EVACUATION WOULD HAVE TO CONTINUE UNTIL THE CHLORINE WAS CLEARED AND THE THREAT TO PUBLIC SAFETY AND HEALTH WAS REMOVED.

NEXT, MR. CHAIRMAN, I WILL DEAL WITH THE "EXPECTATIONS" PORTION OF THE SUBJECT.

I THINK I CAN BE OF MOST ASSISTANCE TO YOUR DELIBERATIONS BY GIVING YOU SOME PERSPECTIVE FROM THE POLITICAL LEVEL AND ALSO HOW I BELIEVE THE MISSISSAUGA INCIDENTS AND OTHER ENVIRONMENTAL THREATS INFLUENCE PUBLIC EXPECTATIONS.

ONE OF THE EFFECTS OF THE MISSISSAUGA INCIDENT WAS TO ALTER THE POLITICAL CLIMATE ON SUCH ISSUES, TO HEIGHTEN PUBLIC CONCERN AND TO SHARPEN PUBLIC ATTITUDES ON SUCH MATTERS.

THE INESCAPABLE FACT IS THAT CLOSE TO A QUARTER OF A MILLION PEOPLE HAD TO VACATE THEIR HOMES AND HUNDREDS OF THOUSANDS MORE WERE INCONVENIENCED IN SOME WAY FOR THE BETTER PART OF A WEEK.

SO UNLIKE MANY OTHER ENVIRONMENTAL ISSUES, THIS EVENT HAD A DIRECT, IMMEDIATE, DISRUPTIVE AND LASTING IMPACT ON A LARGE NUMBER OF OUR CITIZENS.

IN A FASCINATING SURVEY OF EVACUEES, THE INSTITUTE FOR ENVIRONMENTAL STUDIES AT THE UNIVERSITY OF TORONTO POINTS THIS UP VIVIDLY, AND I QUOTE:

"BEFORE THE ACCIDENT, ONLY HALF THE RESIDENTS WERE AWARE THAT HAZARDOUS MATERIALS PASSED BY RAIL THROUGH MISSISSAUGA BUT VERY FEW WERE CONCERNED ABOUT THE RISK. SINCE THE ACCIDENT, HALF OF THE RESIDENTS REPORT A CHANGE IN THEIR FEELINGS AND BELIEVE MORE STRINGENT AND EFFECTIVE CONTROLS ARE NEEDED FOR TRANSPORTING CHEMICALS."

JUST SO WE DON'T FORGET THE EXTRAORDINARY HUMAN DRAMA OF THAT WEEK AS WELL AS THE GOOD WILL AND COURAGE OF THE PEOPLE OF MISSISSAUGA, LET ME RELATE TO YOU ONE OTHER PARAGRAPH FROM THE SECTION OF THE REPORT DEALING WITH THE RETURN OF THE EVACUEES:

"ON RETURNING HOME, ALMOST EVERYONE FOUND THEIR HOUSE EXACTLY AS THEY HAD LEFT IT. HALF THE RESIDENTS FOUND NO MAJOR THINGS THAT THEY HAD FORGOTTEN TO DO. TWENTY-ONE PERCENT REALISED THEY HAD LEFT FOOD OUT WHICH HAD GONE BAD AND 9% HAD LEFT LIGHTS ON OR HEATING TURNED UP TOO HIGH. ANOTHER 9% REPORTED INADEQUATE ATTENTION TO PETS AND PLANTS LEFT FOR A WEEK AND A FEW (2%) HAD FORGOTTEN THAT THEY HAD LEFT FOOD COOKING BUT SUFFERED NO MORE SERIOUS CONSEQUENCES THAN A MESSY STOVE."

IN CONCLUSION, I WANT TO STRESS, PARTICULARLY TO THOSE OF YOU IN INDUSTRY, THAT AS CHAIRMAN OF THE CABINET COMMITTEE ON EMERGENCY PLANNING MY COLLEAGUES AND I DON'T TAKE AN IVORY TOWER VIEW OF THESE MATTERS.

WE RECOGNIZE THAT THESE VARIOUS HAZARDOUS SUBSTANCES ARE NECESSARY FOR OUR WAY OF LIFE AND THAT THERE ARE UNDOUBTED ECONOMIC AND SOCIAL BENEFITS FROM THEM.

BUT IT TROUBLES ME AS A POLITICIAN THAT WE SEEM TO KNOW SO LITTLE ABOUT THE NEGATIVE ASPECTS, THE DANGERS, THE LONG-TERM EFFECTS OF SOME SUBSTANCES AND PRACTICES SOCIETY SEEMS TO TAKE FOR GRANTED - - OFTEN UNTIL IT IS TOO LATE.

THE GOVERNMENT, AS THE REPRESENTATIVE OF THE PUBLIC, HAS THE EXPECTATION THAT INDUSTRY WILL RESPOND RESPONSIBLY AND THAT INDUSTRY WILL LEARN FROM ITS MISTAKES.

REGRETTABLY, I AM COMING TO THE CONCLUSION THAT, AT LEAST AS FAR AS THE RAILWAY INDUSTRY IS CONCERNED, OUR EXPECTATION OF RESPONSIBLE BEHAVIOUR MAY BE MISPLACED.

IN NORTH AMERICA LAST YEAR THERE WERE ALMOST 12,000 INCIDENTS OF WHAT RAILROADERS REFER TO AS "HOT BOXES", THE WHEEL ASSEMBLY MALFUNCTION THAT IS BELIEVED TO HAVE LED TO THE MISSISSAUGA DERAILMENT.

DERAILMENTS OCCURRED AT THE RATE OF MORE THAN FIVE PER WEEK AS A RESULT WHILE SIMPLE DETECTION DEVICES AND BETTER MAINTENANCE AND INSPECTION COULD HAVE PREVENTED MANY OF THEM.

HERE IN ONTARIO THERE HAVE BEEN SEVERAL DERAILMENTS OF HAZARDOUS LOADS SINCE MISSISSAUGA, THE LATEST ONLY LAST WEEK NEAR LONDON WITH ANOTHER, SMALLER EVACUATION.

THE DAY BEFORE THAT DERAILMENT, A CANADIAN TRANSPORT COMMISSION OFFICIAL TOLD THE MISSISSAUGA INQUIRY THAT 27 PER CENT OF THE CARS OF BOTH MAJOR RAILWAYS THAT WERE INSPECTED WERE FOUND TO BE DEFECTIVE AND COULD HAVE CAUSED SERIOUS ACCIDENTS. AND 34 PER CENT OF THE CARS JUST COMING OUT OF THE REPAIR YARDS WERE ALSO DEFECTIVE.

TO INDUSTRY IN GENERAL AND TO THE RAILWAYS AND TO OTTAWA IN PARTICULAR, LET ME SUGGEST THAT THE PUBLIC TOLERANCE FOR THIS KIND OF CONTINUED DISRUPTION AND THREAT TO HEALTH AND SAFETY HAS A LIMIT. AND THAT LIMIT HAS BEEN REACHED.

THIS LACK OF CONCERN FOR THE CONSEQUENCES BY THE RAILWAYS AND FEDERAL REGULATORY AGENCY IS APPALLING.

FINALLY, MR. CHAIRMAN, LET THERE BE NO DOUBT THAT WHEN IT COMES TO STRIKING THE PROPER BALANCE, THE ONTARIO GOVERNMENT WILL RESPOND AS IT DID IN MISSISSAUGA - - BY PUTTING THE SAFETY AND HEALTH OF THE PUBLIC FOREMOST.

Her Worship
Hazel McCallion

Mayor

of

Mississauga

re

Mississauga

Incident

Ladies and Gentlemen:

It's a real pleasure for me to be here this morning. I'm sorry that Mr. McMurtry, our Attorney General couldn't stay. He tells me he's going to get a taping of what I have to say, so I'll have to be cautious. I was hoping he'd be here, and, therefore, I could be less cautious. You know how tapes are cut. I just want to assure you that the tapes of the Mississauga derailment were not cut. The enquiry got them the way it was and maybe that has shaken a few people because it seems that politicians play around with tapes.

I don't know if you know Mississauga, but some of you do I'm sure. We're a city with two major rail lines running through, a number of major highways, the Queen Elizabeth and 401. We have the Mississauga International Airport in our municipality. We're a city where many disasters could happen. Therefore, as a city, we have attempted over the years to prepare for a disaster.

The Mississauga miracle, which it has been adequately termed, was truly a miracle, and just to give you my reasons why I named it a miracle, it happened at an intersection. Can you picture it happening either a half-mile down the track either way in which fire engines and police would have had to find their way through fields, mud holes, and you name it, to get to the scene of the accident? Also at Mavis Road, we have two separate water lines, one on either side of the track feeding that particular area. It happened at five to twelve at night, and being Mayor of the Municipality, I can assure you all our many good Mississaugans are in bed. Certainly the children were.

They weren't separated at public schools, separate schools, secondary schools, colleges, you name it. They were home, most of them, and so were most of the people. And, it happened in an area just a short distance away from a densely populated area. In fact, that intersection is the type of intersection with a road that's not that heavily travelled at that time of night. There are many other intersections in Mississauga where I can assure you there would have been many many more people at the intersection when it happened. There was one car there, and they had a very unusual experience.

I don't know how many of you know the fast-growing municipality that I represent, and I can assure you being Mayor of that fast-growing municipality is sufficient, but if you add a derailment to it, I can assure you it's second to none. Many of the things that the Attorney General mentioned this morning I can assure you land on my desk. I want to give you an example.

He mentioned that the public now is more aware of what the rail lines are transporting through Mississauga. I would like to tell you, and I don't have a count on the number of phone calls I get every week, that a train went by, and this was wrong with it, and that was on it, and there was this and it was going too fast, etc. Never before did I, as Mayor, ever receive a phone call about trains going through Mississauga. So the public is more aware of the situation.

The things I would like to touch with you are some of the things I learned as a local politician.

First of all, I can assure you local politicians fly by the seat of their pants. The senior levels of government who are responsible for rail transportation in this country have, in my opinion, been very neglectful of the rules and regulations that they have established. You may criticize the rail lines, but I believe that the regulations are not in place. I think you should go a bit easy on them. If they are not following the regulations, then it is the responsibility of the Canadian Transport Commission to make sure they are, but unfortunately many of the regulations are not in place.

Would you believe that legislation has been sitting in Ottawa for seven years gathering dust until the Mississauga derailment. Now I'll tell you, everybody is all excited to do something. They've got a standing committee in Ottawa that, in my opinion, is sitting on the issue.

It's interesting how and when the inquiry was called in Mississauga. I want to tell you of my experience as a politician. Mr. McGee came into my office and said -- Mrs. McCallion, we've set the date of an inquiry by the C.T.C. in Mississauga which will happen on December 4th, because I know it would be your wish to have this inquiry in Mississauga, and we're having trouble finding a place in Mississauga.

And I said, Mr. McGee, my wish is that you're not going to conduct this inquiry in Mississauga, and you're not going to find a place here because we are not going to provide you with one. There's no

way that I wanted the hot stove league of Canada to investigate themselves. That's exactly what they were going to do. So I said -- you just sit right there and I'll get in touch with Mr. Mazankowsky in Ottawa.

I called Mr. Mazankowsky and my first comment to him was -- are you completely out to lunch in Ottawa? The C.T.C. responsible for rail transportation in this country investigating themselves? So they were going to look at what they hadn't done, and that would be a long inquiry. Mr. Mazankowsky, within two days, advised me that there would be an inquiry conducted by a judge. An independent inquiry is what we want. We want an independent inquiry on this derailment, and it's long overdue. I can assure you that from the documents that are passing over my desk since the inquiry began, unless the judge just doesn't do a job, and I have every confidence he will, there are going to be changes in this country on the controls and regulations of rail transportation.

I was just down to the Federation of Municipalities in Halifax, and a captain from the Edmonton Fire Department related his experience. He took time one day to go out and inspect a bunch of rail cars on a siding in Edmonton. Twelve of them containing hazardous materials were leaking. That's the type of maintenance we have on the transportation of hazardous materials, and on the rail cars that are carrying them across this country.

Where do the accidents happen? They don't happen in the House of Commons, and they don't happen in the legislatures of this country. They happen in the municipality, and we are the least prepared and least qualified to deal with them, because we are not given either the authority, the tools, or the money to do the job. I don't know if you have ever heard of my explanation of the three levels of government. The Federal Government has all the money, the Provincial Government has all the responsibilities, and the Local Government has all the problems. That's as it relates to the transportation of hazardous materials.

Have you ever thought about who is first at the scene of an accident -- the carrier, because the guy's either driving the truck, or the engineers' driving the train with his staff, or the airplane is being flown by a pilot, or the captain on the boat. And how qualified are they to deal with a disaster or with an accident when they are carrying hazardous material? Have you ever thought of that? The Mississauga incident was a perfect example.

In the United States, because of communication between the senior levels of government and local government, they are now going to require (and I believe the legislation is going into operation this fall), that the the carrier, the guy driving the truck, knows what he's got, knows what to do in the event of an accident, and is thoroughly knowledgeable. If he isn't, he should be checked up the odd time by those who are responsible.

We are to deal with the accident. Do you realize we don't even know what's going through our municipality? Who advises us? I'm not asking that every train and every truck that goes through Mississauga be reported, but I would like to know what type of dangerous materials some time passes through Mississauga. Who has to respond to an accident -- the Fire Department. Wouldn't it be nice for them to know what is going through our municipality? Wouldn't it be nice for the Police Department to know what is going through our municipality? We are ignored. We're not communicated with at all. And how about the routing of hazardous materials? In all, have the rail lines ever looked at the possibility of alternatives or the C.T.C., or the Federal Government, now that Canada is becoming urbanized?

And how about the identification of hazardous materials? You know they put those coloured cards -- what happens to the colour card in the event of an accident? Certainly more research has to be done to determine how the equipment that carries hazardous materials can be better identified, and can withstand a fire, and withstand the type of accidents that happen so that we do know what is in that mess that occurred at the derailment in Mississauga.

And how about the maintenance? What assurance is there? You know the public is getting pretty concerned about the fact that government is supposed to regulate. Government is supposed to monitor. Government is supposed to know whether or not those who are trucking

hazardous materials, or carrying them by rail, are adequate, whether the maintenance on the rail lines is adequate, and whether or not those trucks are properly serviced to carry hazardous materials. My question is who is to do it? Show me where it says, really, who is to do it.

Then we go in one place in which the local municipalities have not played a major role, not the Provincial Government, because we are responsible for land-use planning in our municipality. It never seemed so much at home to me as it did after the Mississauga derailment that our land-use planning should be looked at. We are putting homes within 90 feet of rail lines. In fact, even the railroad companies are becoming concerned about the fact that we're surrounding rail lines with residential development.

The Ministry of the Environment in the Province is responsible for noise in the land-use planning of this Province. I would like to see them take a look at land-use planning from an accident point of view on rail lines and highways. It's not just the air pollution and the noise. We now have to be very concerned about these accidents happening in the residentially developed area, and what might happen in the event of an accident. Have we done that? You answer the question.

Another thing we learned from the disaster is that the crisis communication system is extremely important. The people want to know. The secrecy that surrounds government has got to end. I give you an example, and I know Mr. Cross is going to cover this later.

The burning of PCB's in Mississauga. Unknown to the municipality, approved by the Provincial Government, Certificates issued -- they don't even tell us and, therefore, how can we tell our people. I want you to know of an incident we just had on an experiment at Ontario Research, to give you a comparison, and all hell broke loose when the people found out. I can assure you that it broke loose with me too when I found out that the Province was doing this secretly in our municipality -- the storage of PCB's and the burning, both. The public is getting fed up with government not telling them.

The Ontario Research Foundation wanted to conduct an experiment on the burning of PCB's in a diesel engine. So what did we do? I said, you'll have a public meeting, and we'll call the people together, and we'll discuss it with them. You know what as a result? Of 35 people there, the majority said go right ahead since we now know what it's all about. That's the attitude that we have to take. The public is becoming very disturbed with government and industry that is not prepared to share the information that is so important.

A municipality in Halifax said -- I want to know. I have the largest marshalling yard I believe in Canada. I haven't the slightest idea what is in that yard week after week, and our Fire Department doesn't

know what's in that yard week after week. So if there was an accident or somebody went in and threw a bomb in the middle of it, they don't know what they would be dealing with. By the way, the municipalities are in no way in this Province supported with their fire service, it's strictly on the property tax. We're supported police-wise but not when it comes to fires. I'll tell you today, our Fire Departments have got to become very sophisticated as we industrialize our municipalities. We need some financial assistance from the Province to do that, and I think that's going to be another thing that's going to come out of the Mississauga derailment.

Now, let's get to the clean up. That's interesting. We have a disaster. We have chlorine all over the place. We have caustic soda. We have a mess. Now, my question is, as Mayor, whose responsible for clean up? Well, my good friend here said I'll call you Monday morning Madam Mayor, and in his usually efficient manner, he called me Tuesday morning. I know that he had a problem.

I don't want you to think that I'm being at all critical of the co-operation we got from Mr. McMurtry as Attorney General and coordinator. I don't know how he got there, and I really don't know what his responsibility really is, as I don't know what mine is. So, therefore, we're in the same box. But we did a pretty good job not knowing what our responsibilities were, in my opinion. The departments of the government were very helpful. They were on the spot. They gave us the best advice that they had, and I just want to say that.

Now we come to the clean-up. I said to Graham, look there's private property there and as you know, a municipality has no right to go in on private property. So who is going to clean this mess up. You can go in our parks and recreation land because I can give you authority to do that, but I don't know about the other. Well, I thought the disaster was over until they started to remove the earth from the area by Graham arranging that the C.P.R. and the Peel Regional staff to take the contaminated material to the landfill site in Chinguacousy. That was a disaster. That was the second disaster we were into.

As Graham said, and I will repeat, if we had Bill 24 in place we would know what we could do. Again, here we had a situation and the legislation was not in place to look after it. So that's another thing I learned, that really when it comes to the clean up, it's very difficult to know, and as a politician when I get finished with this, you'll know what I mean by "the Mayor of a Municipality flies by the seat of his or her pants."

That's where the incidents happen. They happen in a municipality. What we need is the Federal Government, the Provincial Government, and the Local Government to sit down and not be operating in a vacuum as now exists. I can assure you that out of this, I'm going to be preparing a brief for the judge, and I can assure you of some of the things I'm going to cover.

Who manages a disaster at the scene of the accident? Sure, I know how the evacuation was conducted, but who takes charge? Have you ever asked that question, and have you found the answers? When you do let me know, I'd like to know.

The Chlorex Team is called in because it was chlorine, right, definitely. They came. Very capable people and they had a problem. They couldn't plug the hole in the chlorine tank. They explained it all to us carefully as to what they were doing, and we made our decision as to what we did with the people based on this expert advice. They worked for a couple of days, and being human, they fell asleep on the job, and there was nobody there to take over from them. We had to wait on a crew to come from Sarnia, and me sitting there with 218,000 people out of their homes, telephoning to find out "when in the world, Madame Mayor, are you going to let us back in?"

So I questioned the management of the incident as to how to deal with these hazardous materials. The Fire Department knew what to do. They knew they couldn't put the fire out because it had to burn off all the propane. They knew what they were dealing with. I'll tell you, the management of how we were to solve the problem, didn't exist. That's when I again phoned Mr. Mazankowsky and got him as he stepped off a plane in Churchill, Manitoba.

We had one guy from the C.T.C. there wandering around in boots, with no authority, just his staff. I asked Mr. Mazankowsky when are they going to get somebody from Ottawa that has some authority to tell us

what should be going on at the scene of this incident. You know what Mr. Mazankowsky's response was to the Mayor of Mississauga? I'll tell you. "Well you know Madam Mayor, I wouldn't want to tread on Provincial jurisdiction." I won't tell you what I said -- it was a very unladylike statement. What I said was, "218,000 people, and you in Ottawa couldn't care less."

So within an hour they had Mr. McGee on the plane to Mississauga. We had him at the table. The C.P. said they were kept out of the discussion. I can assure you no C.P. official asked me whether they could come into the discussion. I just want to make that clear. They were in the discussion the second or third day. I want to give you some advice, if you're ever involved in an incident, make sure that everything is recorded. I tell all my colleagues, as Mayors, don't go in with all these experts without a recording machine because that's the only protection that the Mayor and the elected people have.

So that was my experience, and we're going into law suits. I can assure you that this cost the municipality a lot of money. It cost the residents of Mississauga a lot of money, and I haven't had an offer yet from either level of Government to assist us, and by the way, I haven't asked for it yet either. The point is that we suffered greatly from this incident. I want to assure you that as Mayor of the City of Mississauga, I'm going to leave no stone unturned by putting a bomb under the senior level of the government to get off their seats and do something about the transportation of hazardous materials across this country.

The time has come that the public is not going to accept the wishy-washy regulations and legislation that exist on the books of both the Federal and Provincial Governments. What we need is for local government to be given the authority to do the job, and to be given the tools to do the job, and most important of all, the money to have those at the local level qualified to deal with these incidents. If we haven't learned anything else from the Mississauga disaster or miracle, that is extremely important.

Now there are many who are second-guessing what we did on the evacuation. I'd like to make this comment to you.

If anybody had died, we would have moved too slowly, but nobody died and, therefore, there are those, a very small percentage including somebody who might have a financial interest in this, some large corporation, I wouldn't name them because you can guess who they are, that felt that we kept the people out too long. When you have the lives of 218,000 people in your hands, I can assure you that I have every confidence that we made the right decisions based on the expert advice that was given.

And I say to the fire fighters of Mississauga, to the Policemen and to the fire fighters of many of the areas around and to the Police of many areas around, and to the thousands of volunteers who spent hours at the scene of the incident and contributed freely of time, contributed freely of goods and all the many companies that assisted us

(by the way, we have a \$30,000 writ issued against us for equipment that was provided to us -- I wonder who is going to pick up the tab for that), I just say to you, that everybody performed wonderfully.

The sign that was erected on Dundas Street reads: To the firefighters, to the Police, to the volunteers, and all those who helped, thanks and bless you everyone.

SUPPLEMENTARY PAPER

PROCESS CONSIDERATIONS IN THE TREATMENT
OF WASTEWATER FROM A DETERGENT MANUFACTURING COMPLEX

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INTRODUCTION

Domtar Chemicals through its Chemical Developments of Canada Division Operates a detergent manufacturing complex in Longford Mills (near Orillia) Ontario. The plant produces a relatively low volume but highly concentrated wastewater that is ultimately discharged to Lake St. John. In view of the small size of this Lake, the pollution arising from this plant is of great concern to the cottage owners who use the lake for recreational purposes.

Table 1 summarizes the major unit processes at this plant. Most of the processes are operated in a batchwise manner and, therefore, much of the organics in the wastewater originates from process equipment cleaning.

Washwaters typically contain the chemicals mentioned in Table 1 as well as several hundred other reactants, byproducts and additives. Thus the plants wastewater contains an extremely complex mixture of organic chemicals. Furthermore, the nature of the wastewater fluctuates widely in concentration and flow due to frequent process changeover. Unfortunately the frequency of changeovers is dictated by customer demand and the plant's limited storage capability does not allow for production cycle alterations for the purposes of wastewater equilization. Therefore, Domtar Inc personnel foresaw many potential problems with conventional wastewater treatment systems for such a complex and highly fluctuating wastewater.

Starting in 1965, Domtar and its consultants examined a host of alternatives in an attempt to resolve the problems. As a result of this work, process wastewater and cooling water were segregated and a 350,000 gallon aerated concrete basin was built. The process wastewater was

TABLE 1 Process Types and Organic Contribution

Process No.	Process Unit Name	Process Description	Contribution to Wastewater Organics %
1.	Amide Synthesis	The reaction of fatty acids ethanolamines to make amide type foam stabilizers	2
2.	Nonylphenol Synthesis	The alkylation of phenol with nonere to produce nonylphenol to be used as an intermediate in process 3	4
3.	Nonorganic Detergent Synthesis	The ethoxylation of nonylphenol to make an industrial wetting agent.	12
4.	Carboxy Methyl Cellulose (CMC) Synthesis	The reaction of Cellulose and Sodium Monochloroacetate to produce sodium carboxymethyl cellulose (CMC) part of which is further refined for specialty chemical applications by methanol extraction	45
5.	Sulphonated Anionic Detergent Synthesis	The sulphonation of alkylated benzenes to make linear alkyl benzene sulfonates (LAS) and a subsequent neutralization with ammonium of sodium hydroxides	15
6.	Cationic Detergent Synthesis	The reaction of tertiary (fatty acids) amines with methylchloride to produce a quarternary ammonium chloride	2
7.	Detergent Formulation	The blending of the tertiary chemicals to produce the final detergent products	15
8.	Boiler Blowdown and Yard Drainage	See stream title	5

then directed to the basin for treatment prior to discharge. Unfortunately organic removals were quite low varying from 0% in the winter to 20% in the summer. Subsequently various other alternatives were proposed to improve the wastewater treatment system, however, none were judged to be adequate by the company.

In the fall of 1975 a combined internal external task force was formed to develop a usable process design for adequately treating Longford Mills wastewaters by the end of 1976 in answer to a request by the Ontario Ministry of the Environment. The four authors of this paper constituted the task force.

In view of the complexity of the problem, Domtar Inc. felt that to the maximum extent possible process development should be done by internal staff who understand the complexities of the plant and can provide detailed guidance to the central engineering arm of the company. Thus external advice was limited to specialized chemical engineering based environmental expertise as needed.

The task force had the following specific objectives

- (i) to carry out an analysis of wastewater sources and to implement an in plant minimization of process waste production
- (ii) to examine different process alternatives and to evolve a reliable and affordable process
- (iii) to carry out the design of the chosen process

By December 1976, the required design was completed. The plant was

constructed and started up by December 1977 and the plant has operated continuously ever since.

During the steps leading to the process design and the first two years of operation some widely useful information has been generated on the treatment of industrial wastewater and the purpose of this paper is to make this information available to the environmental engineering community.

WASTEWATER SOURCE ABATEMENT

A wastewater source abatement program was undertaken to

- (i) to determine the contribution of each process area (as described in Table 1) to the plant's "raw" wastewater.
- (ii) to reduce wastewater volume, concentration, and concentration fluctuation whenever economically and technically reductions were possible.

The first objective listed above was easily accomplished through a thorough sampling program. At the end of the sampling program, the major pollution sources were identified and quantified. Process equipment wash water was identified as a major source of pollution in almost all process areas and studies were undertaken to determine washout concentration as a function of time in each major process vessel. Figure 1 displays the typical results of these washout studies; as expected most process equipment displayed the washout characteristics of completely stirred tank reactors (CSTR).

From these graphs for each of the major products cut off times were determined in order to maximize product recovery in the wash water for

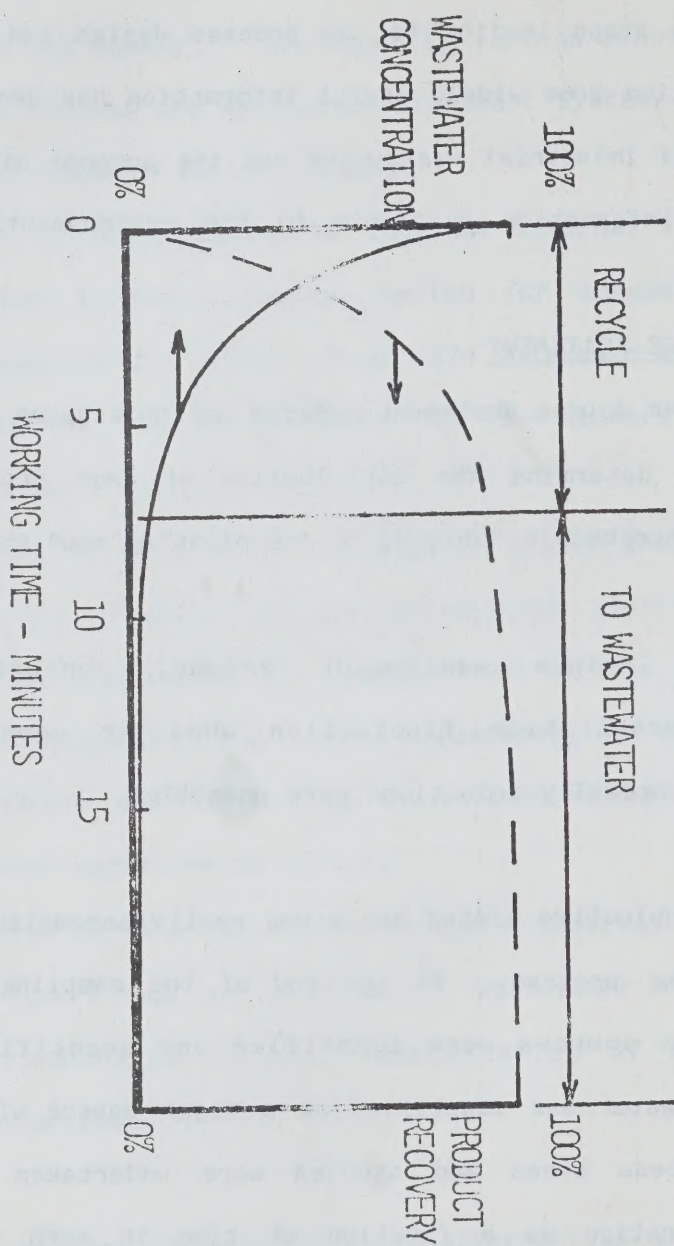


FIG. 1 TYPICAL DATA SHAPES OBTAINED DURING TANK CLEANING STUDIES

recycling and secondly to minimize the length of washout time, after which the relatively uncontaminated washwater would be diverted to the contaminated wastewater process streams. Fortunately, product quality studies indicated that much of the high concentration wastewater could be blended into product formulation.

The above procedure was adopted for all reaction vessels, product storage tanks, automatic drum/pail fillers, transfer pipes and hoses, etc.

In addition to the recycled washwater system the following procedures were also implemented:

(i) Larger storage tanks were installed to increase length of production campaigns thus decreasing the number of washups.

(ii) The education of all employees including Management, Sales and operators was undertaken to make them more aware of the importance of product scheduling, keeping materials out of drains, use of recycled washwater without loss of product quality or decreased production versatility or customer service.

(iii) Ball washers were installed in reaction vessels and multi product tanks.

(iv) In order to facilitate product tank washouts and drainage, tank bottoms were sloped to the exit line or where this was impossible tanks were slightly tilted thus decreasing product heels left in tanks when switching from one product

to another.

- (v) Packing glands on pumps were replaced by mechanical seals wherever practical.
- (vi) Drip trays were installed to keep dribs and drabs out of drains.
- (viii) Vacuum pump seal water was recirculated wherever possible.
- (ix) In some cases drains were filled with concrete and replaced with oil absorbent materials on floors which was swept up when contaminated.
- (x) Special washwater tanks were set up to store washwater for subsequent use of formulations and during the annual two week plant shut down this water is used as feed wastewater to the treatment plant.

The above inplant abatement program decreased COD loadings in the plant's effluent from 510 Kg/day to 280 Kg/day. This equates to a 45% decrease in spite of the fact that at the same time plant production increased by approximately 15%. The cost of this phase of the program was approximately 10% of the total pollution abatement program or approximately \$47,000.

PROCESS DEVELOPMENT STUDIES

The characteristics of the combined plant wastewater were determined on the basis of an extended sampling program and the averaged results are shown in Table 2.

As shown in Table 2, the organic concentration parameters were approximately ten times greater than those encountered in domestic wastewater while suspended solids were relatively low in concentration.

The identified primary organic constituents of the combined wastewater were believed to be phenols, anionic detergents and, during the production of refined CMC, methanol.

In general detergent molecules were expected to be either difficult to degrade or nondegradable. Furthermore significant wastewater concentration variations were expected. Thus a physicochemical treatment was deemed to be desirable for detergent removal. On the other hand, significant methanol concentrations were expected and, as methanol is easily treated biologically but not physicochemically, biooxidation also seemed to be a necessity.

A total of five different process alternatives were examined as listed in Table 3 below. Simple batch tests were conducted for each process to determine the process parameters needed for approximate (+25%) capital cost estimation. The resulting costs are shown in Table 3. On the basis of capital and operating cost considerations the lime plus biooxidation or the biooxidation plus filtration process appeared to be most desirable. In the case of the lime treatment, potential sludge handling problems were foreseen and, therefore, biooxidation followed by filtration was judged to be the most desirable process assuming that biooxidation without physicochemical pretreatment can be

Table 2 Expected "Design" Characteristics of Raw Wastewater and Motreated Effluent

Parameters	Average Concentration (mg/l)	
	Wastewater before treatment	Treated Wastewater
Flow-IGPD	30,000 IGPD	30,000 IGPD
Filtered COD mg/l	3500	340
BOD ₅ -mg/l	2400	100
Suspended - mg/l		
Solids	130	130
Total Phosphorus		
as P-mg/l	3	1.5
pH	8.0 to 10 pH Units	7.0 to 8.5 Units
Phenol	45	.020
MBAS	200	1

TABLE 3 Alternative Processes Considered and Their Capital Cost Estimates

Process	Capital Cost Estimates
(i) Granular Carbon Adsorption with Biological Effluent Polishing Lagoon	\$988,000
(ii) Lime Precipitation Followed by Activated Sludge Biooxidation	\$319,000
(iii) Activated Sludge Biooxidation with Powdered Activated Carbon Addition	\$470,000
(iv) Ion Exchange Followed by Activated Sludge Biooxidation	\$580,000
(v) Activated Sludge Biooxidation followed by Filtration	\$460,000

shown to work reliably.

A series of laboratory batch and pilot scale continuous studies were, therefore, undertaken to determine process reliability and to develop design parameters.

Initially a set of batch biodegradation studies were conducted in respirometers on each of the streams listed in Table 1. On the basis of these studies the following knowledge was gained

- (i) The organics in all streams are biodegradable with the exception of the cationic detergent stream,
- (ii) The cationic detergent stream is not toxic to bacteria at the concentrations normally encountered at the plant,
- (iii) Biodegradation is highly sensitive to concentration and in some cases the waste streams had to be diluted as much as tenfold before biodegradation could proceed.

The last of the above observations merits further discussion. Respirometry studies on the nonionic detergent synthesis stream (No. 4 in Table 1) indicated that this stream is non-biodegradable. On the other hand, there were numerous studies in the literature suggesting that the major component of this stream (ethoxylated nonylphenol) is at least partially biodegradable in a domestic wastewater treatment plant (Mann and Reid, 1971; Stiff et al 1973; Rootham and Stiff 1976). In general, these studies indicated that the biodegradation was incomplete at inlet concentrations above 5 mg/l and temperatures below 15°C (Stiff et al 1973). Rootham and Stiff (1976) concluded, however, that the

"biodegradation of alkylphenol ethoxylates is subject to wide variation and can not be predicted from the present state of knowledge".

One major difference between our studies and those reported in the literature was the fact that domestic wastewater contains a mixture of biodegradable substances whereas stream 4 was probably a solution of ethoxylated nonyl phenol only. Thus an attempt was made to add to the solution another more readily biodegradable substrate.

The result of the respirometric study is shown in Figure 2. In parallel with the respirometric studies TOC measurements were also made and these are tabulated below.

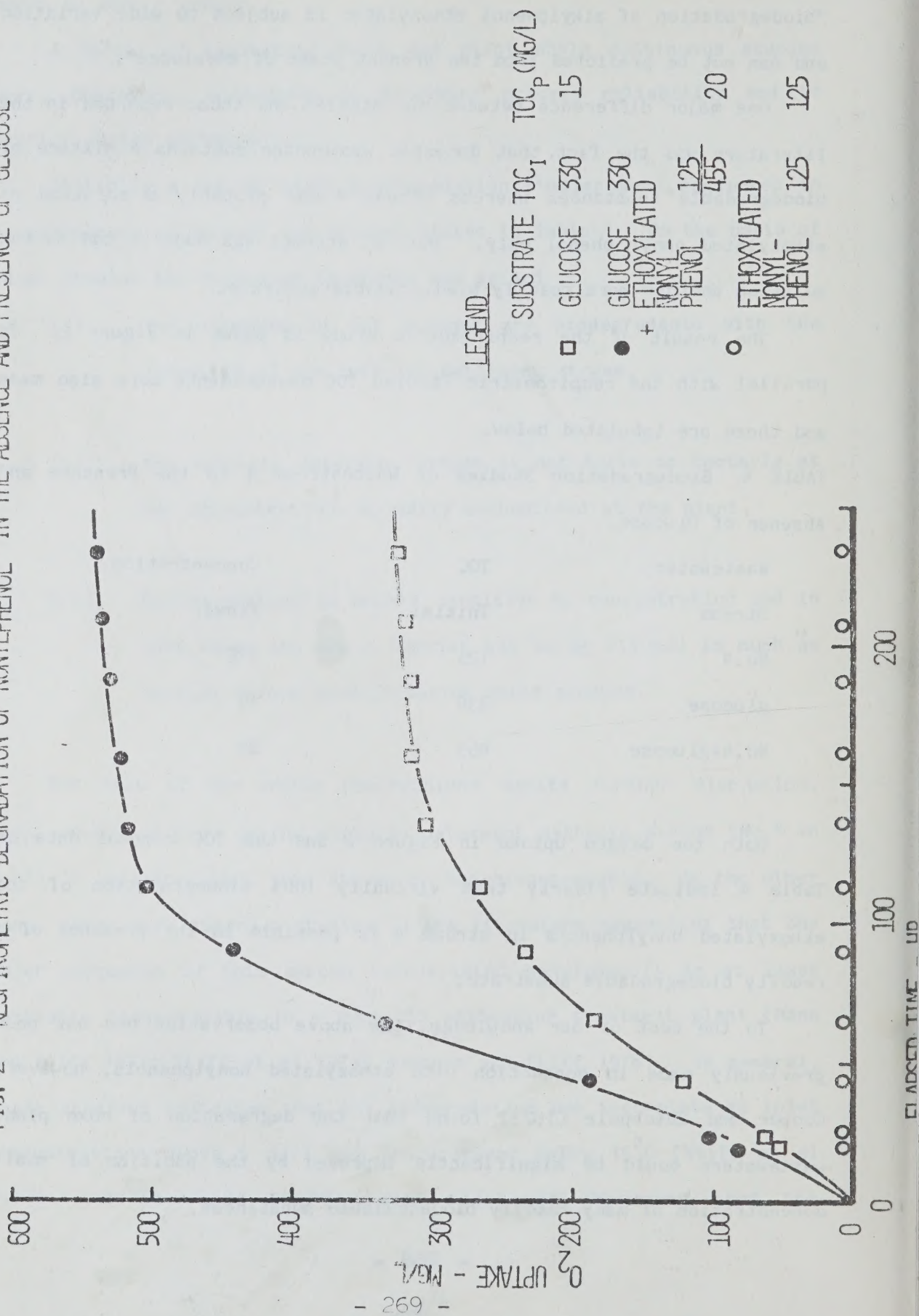
TABLE 4 Biodegradation Studies on Wastestream 4 in the Presence and Absence of Glucose.

Wastewater	TOC	Concentration
Stream	Initial	Final
No.4	125	125
glucose	330	15
No.4+glucose	455	20

Both the oxygen uptake in Figure 2 and the TOC removal data of Table 4 indicate clearly that virtually 100% biodegradation of the ethoxylated nonylphenols in stream 4 is possible in the presence of a readily biodegradable substrate.

To the best of our knowledge, the above observation has not been previously made in connection with ethoxylated nonylphenols, however, Cooper and Catchpole (1973) found that the degradation of coke plant wastewaters could be significantly improved by the addition of small concentration of many readily biodegradable substances.

FIG. 2 RESPIROMETRIC DEGRADATION OF NONYLPHENOL IN THE ABSENCE AND PRESENCE OF GLUCOSE



After the individual stream studies were completed, a pilot activated sludge unit was set up at the plant. The pilot study pointed out two major problems:

- (i) a relatively low organic loading (expressed as food to microorganism ratio or F/M) of 0.1 lb COD/lb MLSS/d was noted as a requirement for adequate biodegradation
- (ii) the bacteria grew as a dispersed floc, in spite of the low F/M ratios used and were, therefore, difficult to settle.

Extensive batch sedimentation tests (as described by Bancsi and Benedek (1975) were run on the aeration tank effluent of the pilot plant and Figure 3 illustrates a typical set of results.

In the case of the data in Figure 3, clarification for thirty minutes in a jar still resulted in a supernatant suspended solid (SS) concentration of 300 mg/l. On the other hand, if only 50 mg/l of alum as $\text{Al}_2(\text{SO}_4)_3 \cdot 14 \text{H}_2\text{O}$ is added, the effluent SS concentration dropped to less than 50 mg/l. Similarly, supernatant phosphorous levels also dropped rapidly with the addition of alum.

In Ontario, all plants discharging into the Lower Great Lake Water System must meet a total phosphorous level of 1mg/l or less 60% of the time, although, more stringent requirement would have to be met by this plant due to its location on a small lake. Thus alum use could be justified on the basis of the improvement in solid sedimentation as well as phosphorous precipitation.

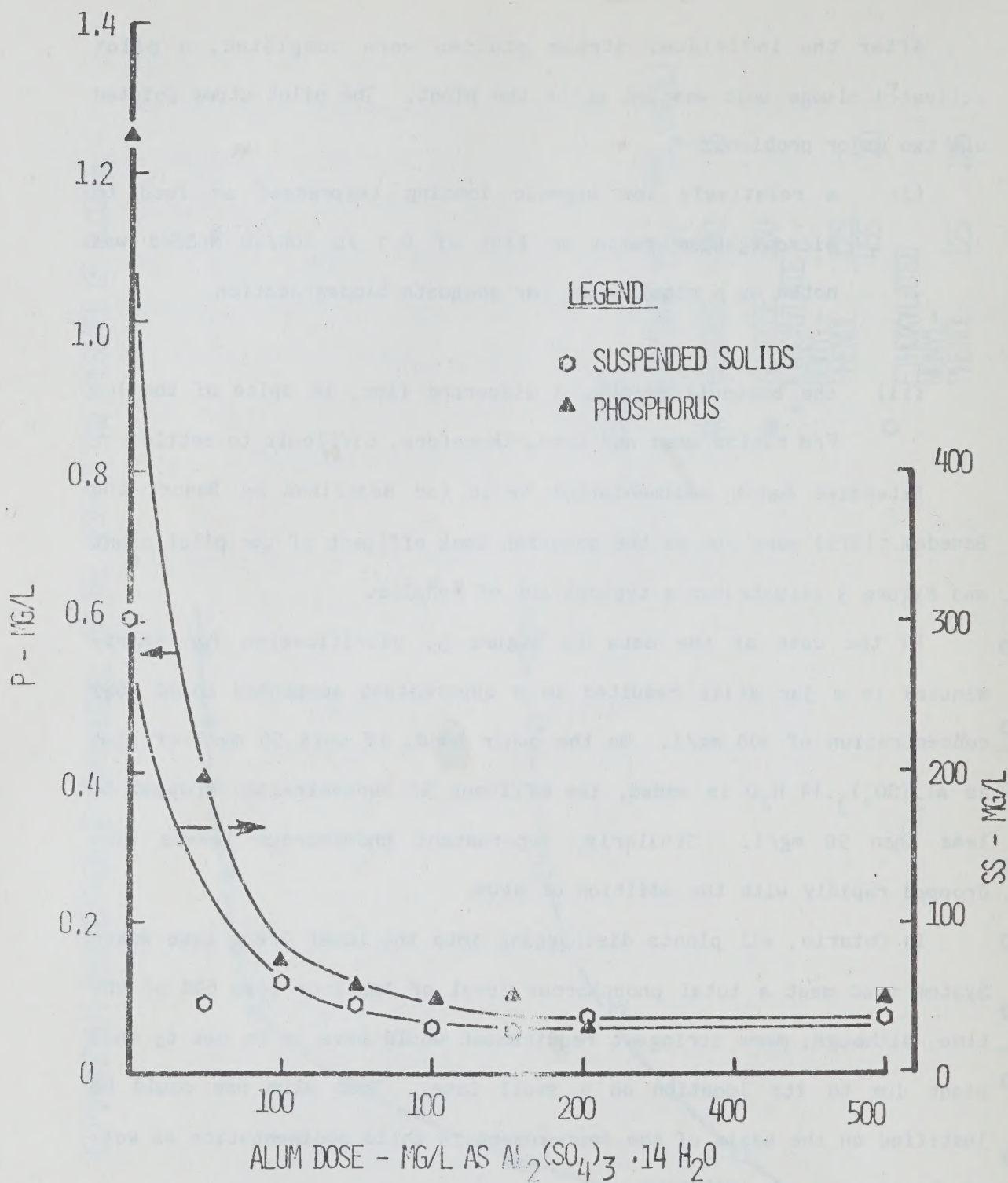


FIG. 3 THE EFFECT OF ALUM ON THE REMOVAL BY CALRIFICATION OF SUSPENDED SOLIDS AND PHOSPHORUS FROM MIXED LIQUOR

PROCESS DESIGN

As noted earlier, it was decided to use activated sludge as the main organic removal process followed by tertiary sand filtration if necessary to meet the Ministry of the Environment's requirements for maintaining the water quality of Lake St. John. Due to the small size of the Lake, these requirements were expected to be 15 mg/l BOD₅ (5 day Biochemical Oxygen Demand), 15 mg/l SS, and 0.3 mg/l total Phosphorous (as P). The tertiary sand filtration step was thought to be necessary for phosphorous removal, although, serious concerns were raised that the expected high level of suspended solids in the secondary effluent may cause operational problems. Furthermore, a special alum addition line was designed to remove phosphorous and to aid suspended solids removal (see below) and this system was believed to be potentially capable of meeting the Ministry's requirements. Thus the Ministry of the Environment and Domtar agreed to proceed with an activated sludge plant only and, in response to this agreement, Domtar submitted a request for Design Approval in December 1977.

The design inlet and outlet concentrations for such a plant are shown in Table 3. These concentrations were conservatively estimated from the pilot plant data; the full scale plant was expected to perform considerably better due to an improved suspended solids coagulation and clarification capability and continuous rather than semi continuous feed addition and sludge recycle. If, on the other hand, the expected improvements in plant operation would not materialize, consideration would be given to the installation of tertiary sand filtration in an attempt to meet the Ministry's requirements as discussed earlier.

Table 5 lists the process problems considered during the design of the activated sludge process and solutions suggested by the process development work described earlier.

These problems and solutions were then considered in the choice of the process flowsheet shown in Figure 4. There are several novel features of this plant and these are described in detail below.

Lack of primary treatment

The low suspended solids concentration in the wastewater suggested that a primary clarifier would be superfluous.

Equilization in the Aeration Tank

Frequently, in chemical plants, where spills are encountered, upstream equilization basins are built. In this case, inplant modification were built for most process areas to minimize spills and, in the case of the CMC refining unit, a preequilization tank was installed (see below). On the other hand, the cost of equilization for the entire process flow would have been prohibitive.

At the same time, the process development stage suggested a very low F/M ratio which in turn meant a very long hydraulic residence time. Fortunately the existing aeration pond, described in the introduction, could adequately serve as the aeration tank of the activated sludge plant. The hydraulic residence time, assuming a sludge recycle of 60% and an aeration tank volume of 280,000 IG, is then equal to six days.

The aeration tank design is shown schematically in Figure 5. Volumetric equilization is accomplished by pumping at a constant rate slightly higher than the influent plus recycle flow and is typically set at or below 58,000 IGPD (imperial gallons per day). The pump automatically shuts off when the level of the aeration tank is 10 ft.

TABLE 5 Potential Problems and Solutions Considered in Process Design

Problem No.	Problem Description	Solution Description
1.	Potential for Spills	Equilization
2.	Slow and Difficult Biodegradation	Low F/M ratios
3.	Temperature sensitive Biodegradation	Floating Covers and Steamheating
4.	Foaming	Large Bubble Size Aeration
5.	Need for Easily Degrading Substance	In-plant Equilization of Methanol stream
6.	Dispersed Bacterial Growth	Alum Addition
7.	Phosphorous Removal	Alum Addition
8.	High Feed pH	Alum Addition, Phosphoric Acid Addition or Acid or Base Addition as needed

FIG. 4 SCHEMATIC OF THE WASTEWATER TREATMENT PLANT

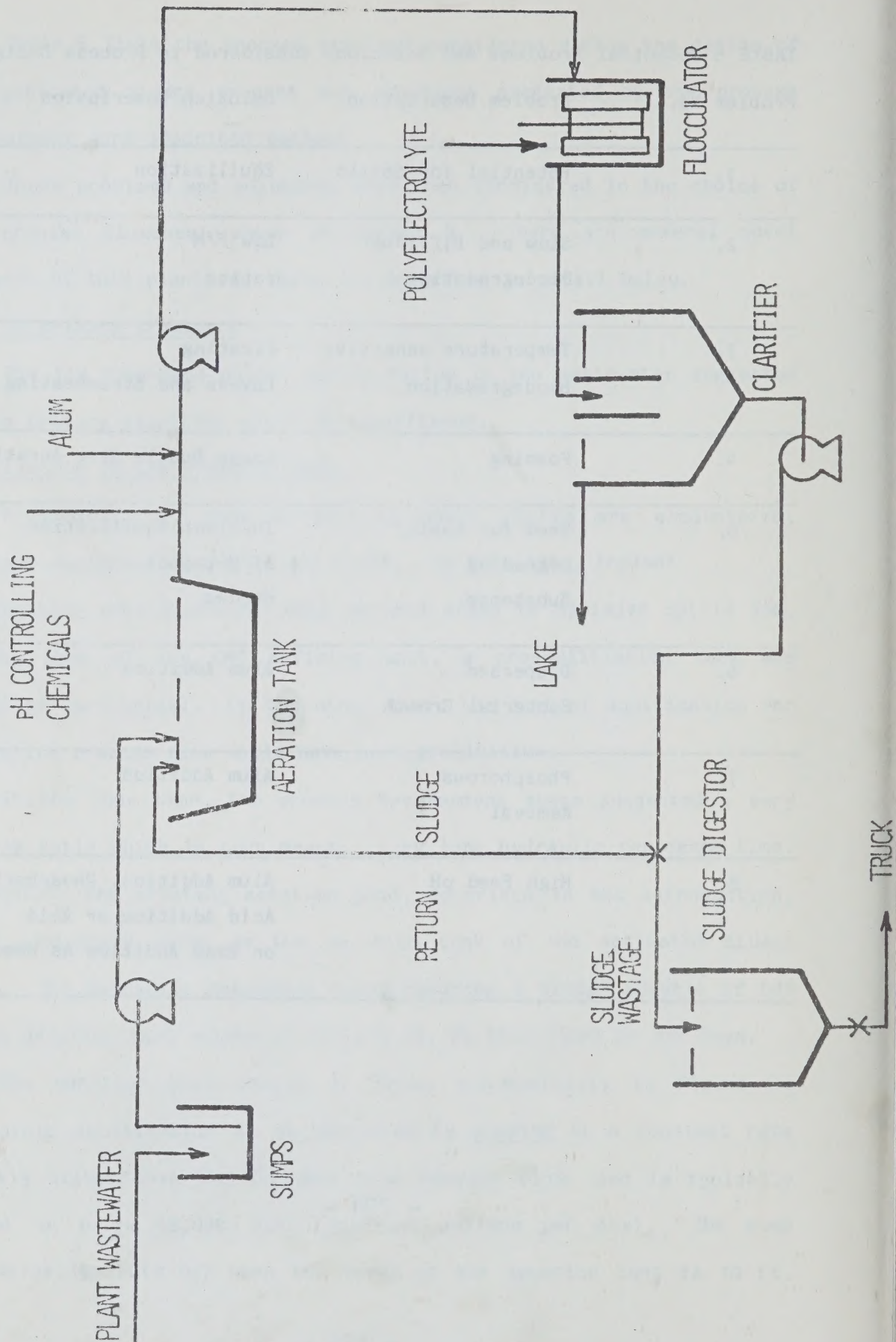
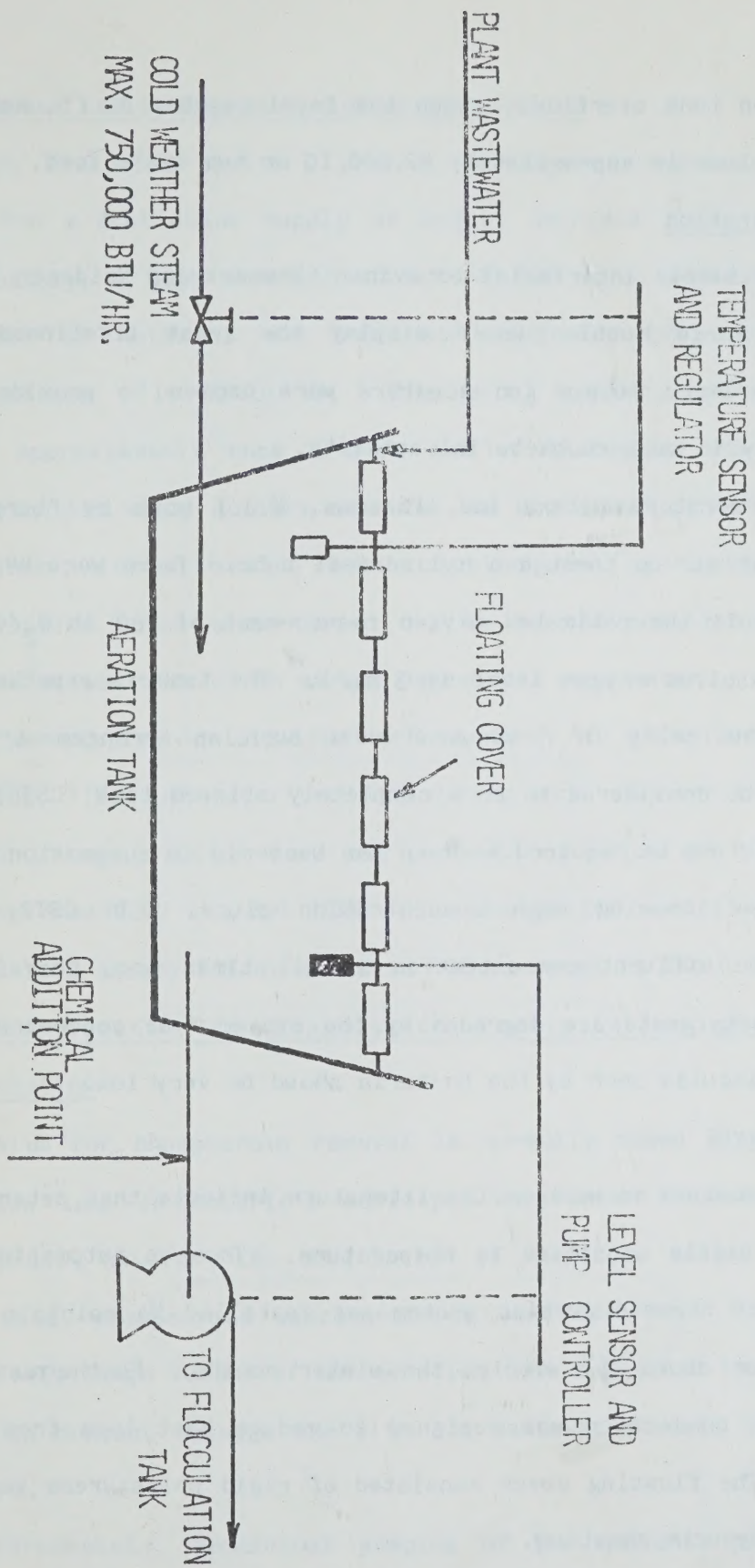


FIG. 5 THE DESIGN OF THE AERATION TANK FOR EQUILIZATION



and the aeration tank overflows. When the level reaches 12 ft. maximum equilization volume is approximately 92,000 IG or two day's feed.

Large Bubble Aeration

Studies on bubble interfacial behaviour (Benedek and Heideger 1971) indicate that large bubbles would display the least likelihood for foaming. Thus large bubble gun aerators were chosen to provide the oxygen necessary to support bacterial activity.

These gun aerators (Atara Inc. Paramus, N.J.) work by "burping" fixed volumes of air up through a cylindrical tube. There were 44 guns required to supply the estimated oxygen requirement of 760 lb O_2 /d and the average dissolved oxygen level of 3 mg/l. The tank is expected to turn over hydraulically in 7 minutes under such an arrangement and, therefore, can be considered to be a completely stirred tank (CSTR). A high level of mixing is required to keep the bacteria in suspension and, also, to dilute incoming high concentration slugs. In CSTR, the bacteria see the effluent concentration at all times and, therefore, assuming that detergents are degraded by the system, the concentration of detergent molecules seen by the bacteria should be very low.

Temperature Control

The pilot studies as well as the literature indicate that detergent degradation is highly sensitive to temperature. Thus an automatically controlled direct steam injection system was installed to maintain the temperature at or above 15°C during the winter months. Furthermore, a simple, floating pond cover was designed to reduce heat loss from the pond surface. The floating cover consisted of rigid polystyrene boards covered with polymeric sheeting.

Continuous Easily Degrading Substrate Addition

As discussed earlier, process development studies indicated the need for a continuous supply of easily degraded bacterial substrate. Fortunately, a high strength (COD 28,000 mg/l) wastewater primarily composed of methanol was available from the CMC refining process (Wastestream 4 in Table 1). This unit, however, operated for short times approximately once a week and at that time its high organic concentration would quickly overload the biological system.

Thus, fortuitously, the solution the overload problem was equilization which also turned out to be the solution to the needed continuous addition of an easily degradable wastewater.

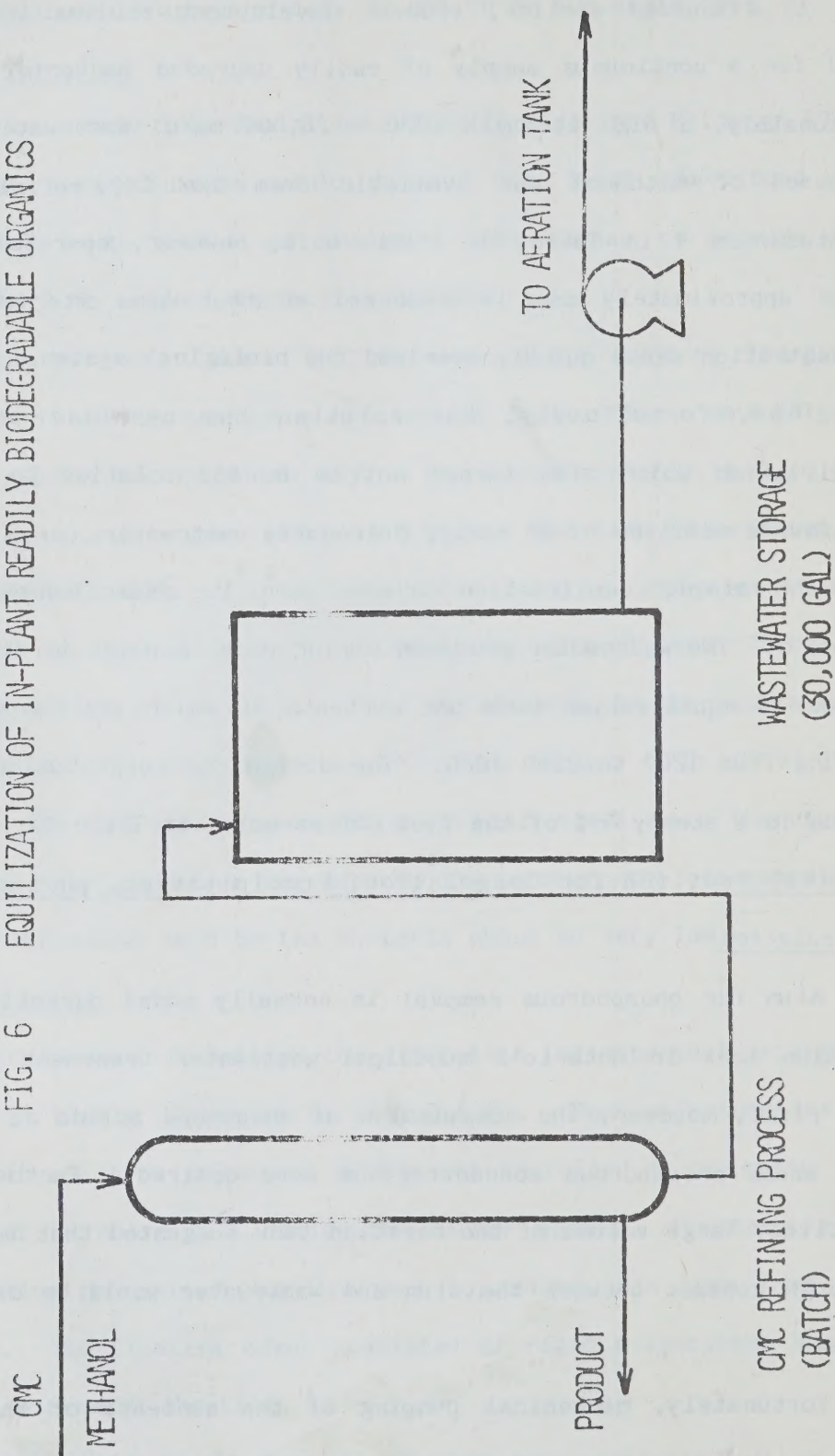
The simple equilization scheme used is shown schematically in Figure 6. The wastewater produced during each campaign is directed to a 30,000 IG equilization tank the contents of which are pumped at rates ranging from 1200 to 2200 IGPD. The design COD contribution from this source is a steady 45% of the feed COD as noted in Table 1.

Chemical Addition for Coagulation, Precipitation, pH control, and Flocculation

Alum for phosphorous removal is normally added directly into the aeration tank in Ontario's municipal wastewater treatment plant. In this plant, however, the coagulation of suspended solids as well lower than usual phosphorous concentrations were desired. Furthermore, the relatively large volume of the aeration tank suggested that the required thorough contact between the alum and wastewater would be difficult to achieve.

Fortunately, mechanical pumping of the contents of the aeration tank to the clarifier was already planned for equilization needs (as

FIG. 6 EQUILIZATION OF IN-PLANT READILY BIODEGRADABLE ORGANICS



outlined above). Thus it became relatively simple to design an in-line chemical addition system as outlined in Figure 7.

The addition of alum to the suction side of a centrifugal pump has been shown to result in excellent alum/wastewater contact (Benedek et al 1975) and, therefore, this was the practice followed in design. Furthermore, provisions were made for polymeric flocculant addition (see Figure 7), for the case of particularly poorly settling SS. Finally, a flocculation tank was installed to allow time for the development of large easily settleable flocs prior to clarification. The flocculation tank also serves as the chemical addition point for polyelectrolyte addition.

CONSTRUCTION

Ground was broken in June 1977 and the construction proceeded uneventfully during the rest of 1977. The plant was ready for start-up by late December 1977, although, some small items (e.g. flowmeters) still remained to be added during 1978.

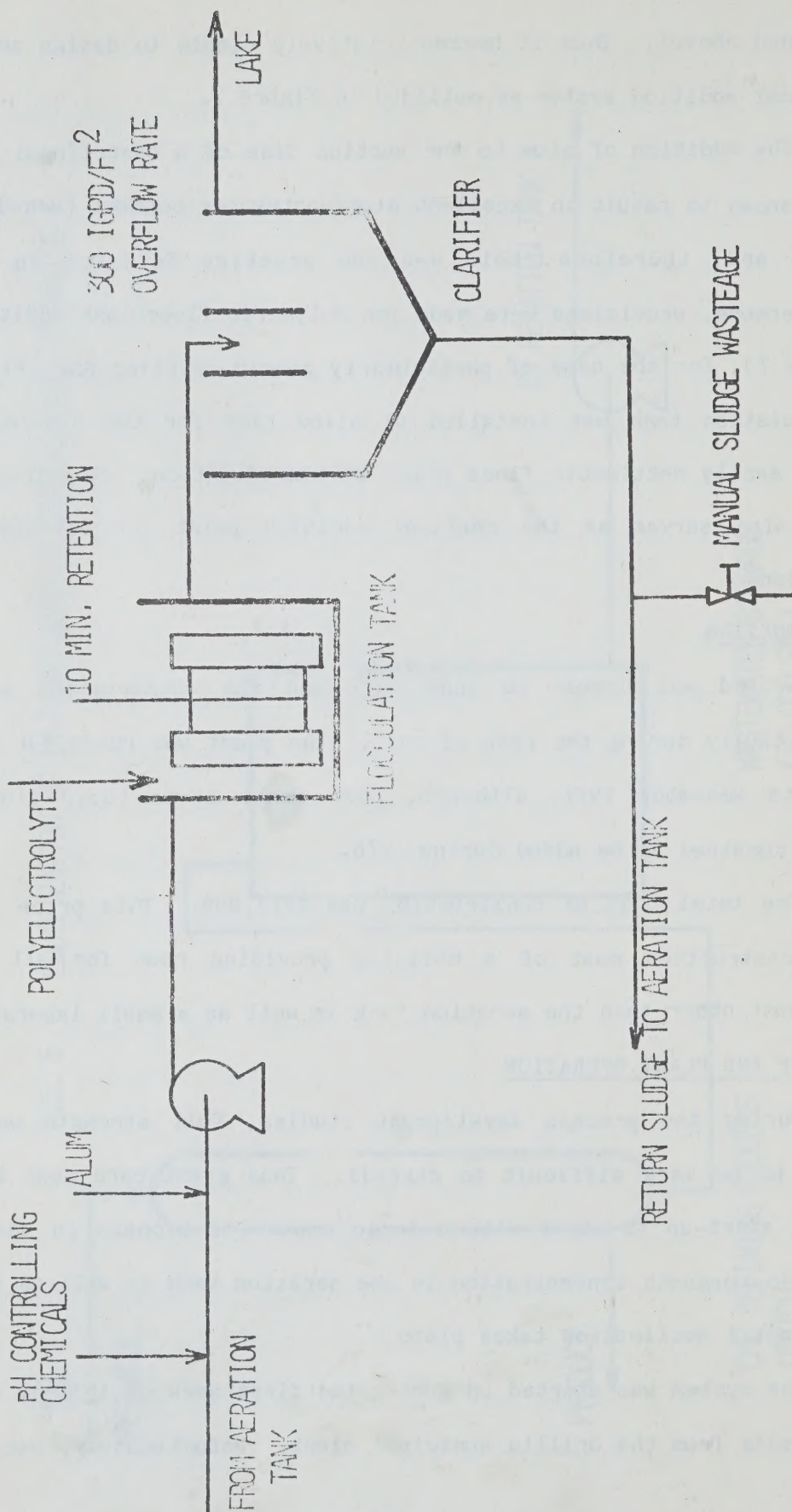
The total cost of construction was \$471,000. This price included the construction cost of a building providing room for all process equipment other than the aeration tank as well as a small laboratory.

STARTUP AND PLANT OPERATION

During the process development studies, full strength waste was shown to be very difficult to degrade. Thus great care must be taken during start-up to start with a large amount of biomass in the system and a low organic concentration in the aeration tank as well as the feed water until acclimation takes place.

The system was started up during the first week of 1978 by bringing in biomass from the Orillia municipal plant. Unfortunately, the biomass

FIG. 7 ALUM AND POLYELECTROLYTE ADDITION FOR THE REMOVAL OF SUSPENDED SOLIDS AND PHOSPHORUS DURING CLARIFICATION



concentration in the Orillia plant was low at this time and there were several spills at the plant during the first month of start-up. As a result, significant loss of biomass occurred coupled with excessive foaming and another attempt at start up had to be made one month later. This time the Orillia plants sludge was three times as concentrated as before and the plant started up successfully as shown in Figure 8.

During the first month Figure 8 shows that only 54% of the BOD applied to the plant was removed and much of this removal must have occurred by dilution. During the next two months BOD removal rose to a value consistently in excess of 80%. During the initial 9 months biomass concentration consistently increased (see Figure 9) subsequently the biomass level or MLVSS (mixed liquor volatile suspended solids) still increased although at a much slower rate and in a more oscillatory pattern.

The effect of high biomass level is remarkable in terms of the BOD removal results of Figure 8. A BOD_5 removal of 97% was reached during the tenth month of operation essentially corresponding to the levelling off of the biomass in Figure 9 and, after the thirteenth month, BOD removal consistently exceeded 99%.

The results in terms of BOD removal are not quite as sensitive to the value of the F/M ratio as this parameter essentially remained constant at a value of 0.03 day^{-1} after the fourth month of operation.

As shown in Figure 10, the high BOD removals after the 13 months of operation also corresponds to the decrease in SS level such that the level of BOD_5 in the treated effluent equalled the level of SS; a condition indicating that soluble BOD_5 is no longer present in the effluent since 1 mg/l of biomass is generally considered to have a BOD

FIG. 8 MONTHLY AVERAGE REMOVAL OF BOD₅

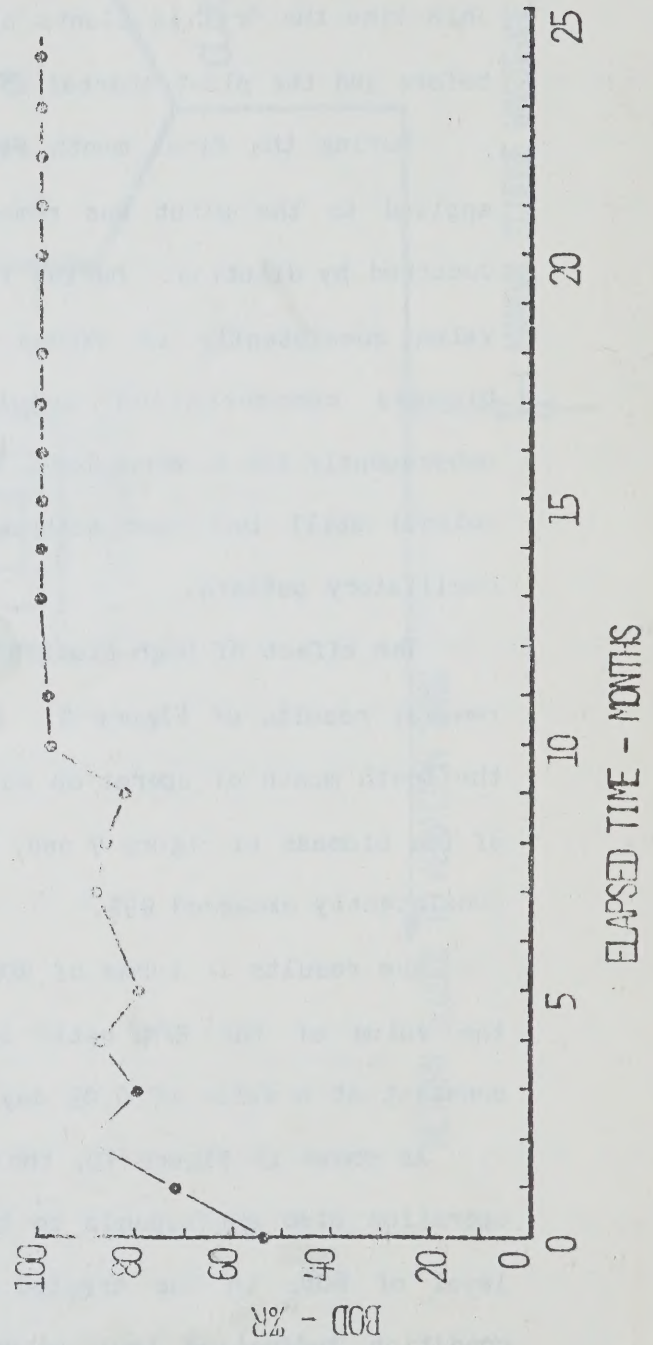
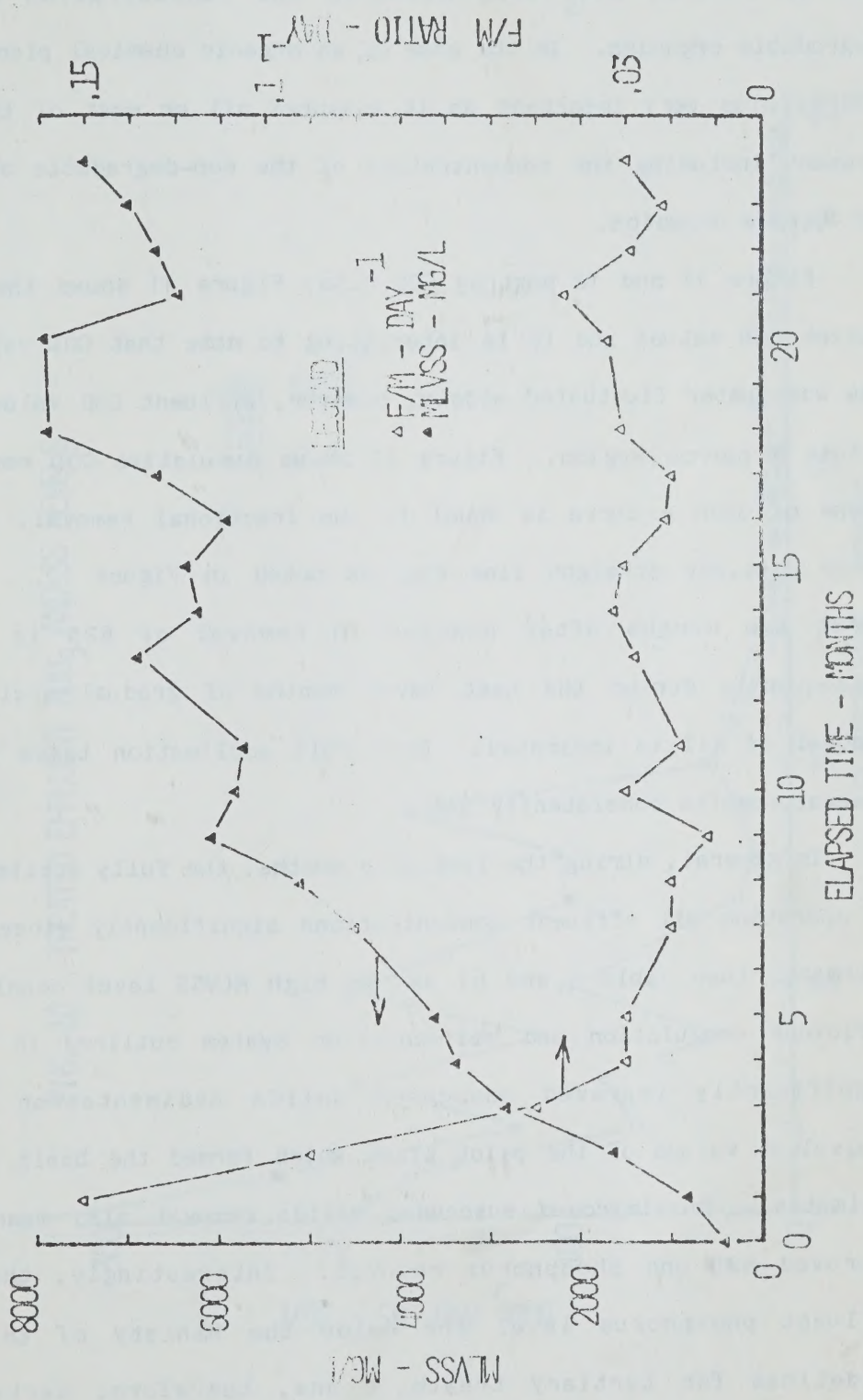


FIG. 9 MONTHLY AVERAGE F/M RATIOS AND MLVSS VALUES



of 1 mg/l. Prior to the tenth month of operation, soluble BOD_5 removals were clearly incomplete as the BOD_5 levels tended to exceed considerably the SS levels, BOD_5 only measures the concentration of readily degradable organics. In the case of an organic chemical plant, however, COD is also very important as it measures all or most of the organics present including the concentration of the non-degradable or difficult to degrade organics.

Figure 11 and 12 portray COD data; Figure 11 shows the inlet and outlet COD values and it is interesting to note that COD values in the raw wastewater fluctuated widely, however, effluent COD values remained within a narrow region. Figure 12 shows cumulative COD removals, the slope of such a curve is equal to the fractional removal. There are three distinct straight line regions noted in Figure 12. During the first two months after start-up a removal of 62% is obtained, subsequently during the next seven months of gradual acclimation, a removal of 81% is indicated. Once full acclimation takes place, the removal remains consistently 93%.

In general, during the last nine months, the fully acclimated phase of operation all effluent concentrations significantly exceeded design estimates (see Table 3 and 6) as the high MLVSS level coupled to the efficient coagulation and sedimentation system outlined in Figure 7, significantly improved suspended solids sedimentation over the equivalent values of the pilot plant which formed the basis for design estimates. The improved suspended solids removal also meant greatly improved BOD and phosphorus removal. Interestingly, the current effluent phosphorus level are below the Ministry of Environment guidelines for tertiary treatment and, therefore, tertiary sand

FIG. 10 TREATED EFFLUENT BOD₅ AND SS LEVELS

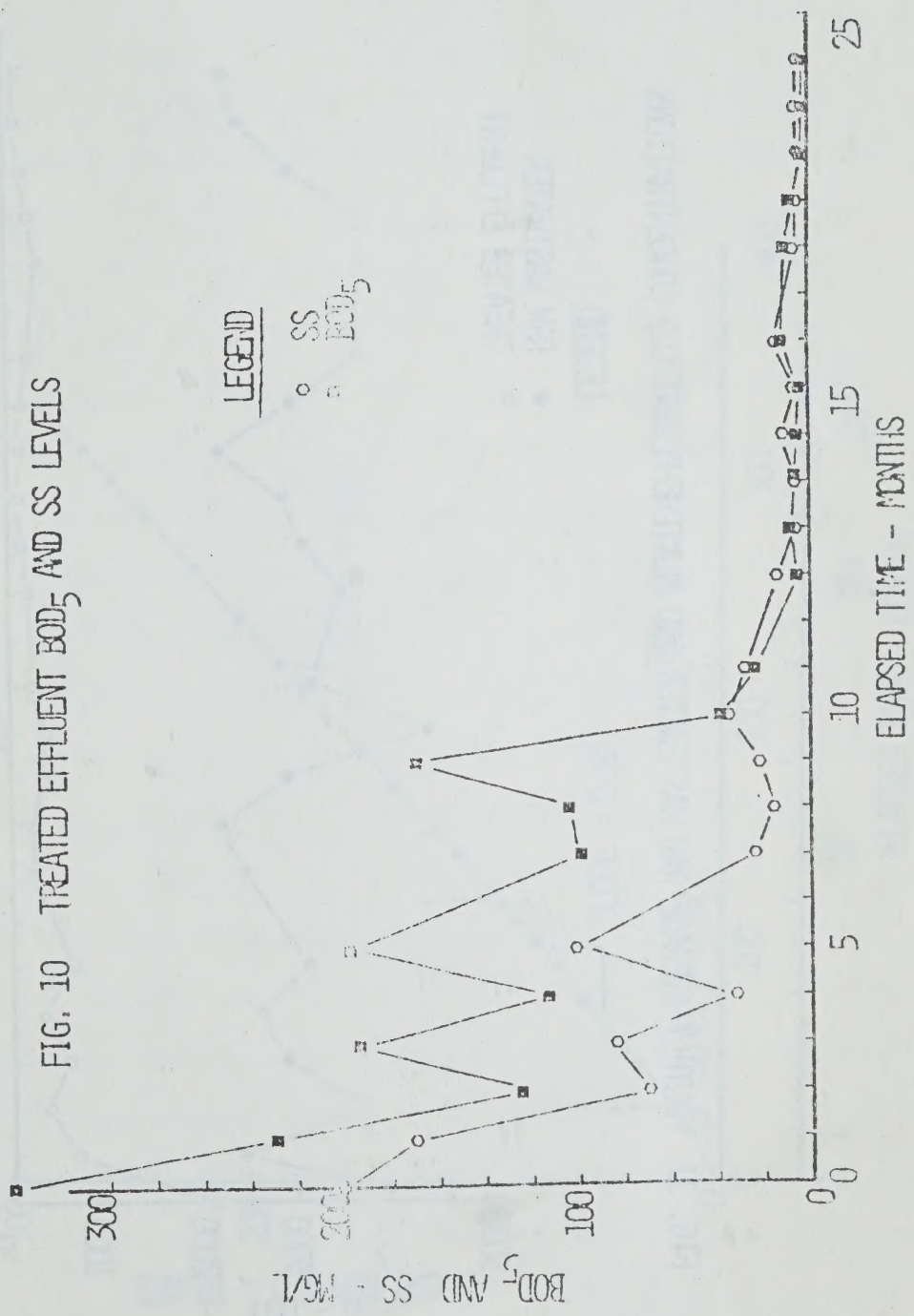


FIG. 11 MONTHLY AVERAGE RAW WASTEWATER AND PLANT EFFLUENT COD CONCENTRATIONS

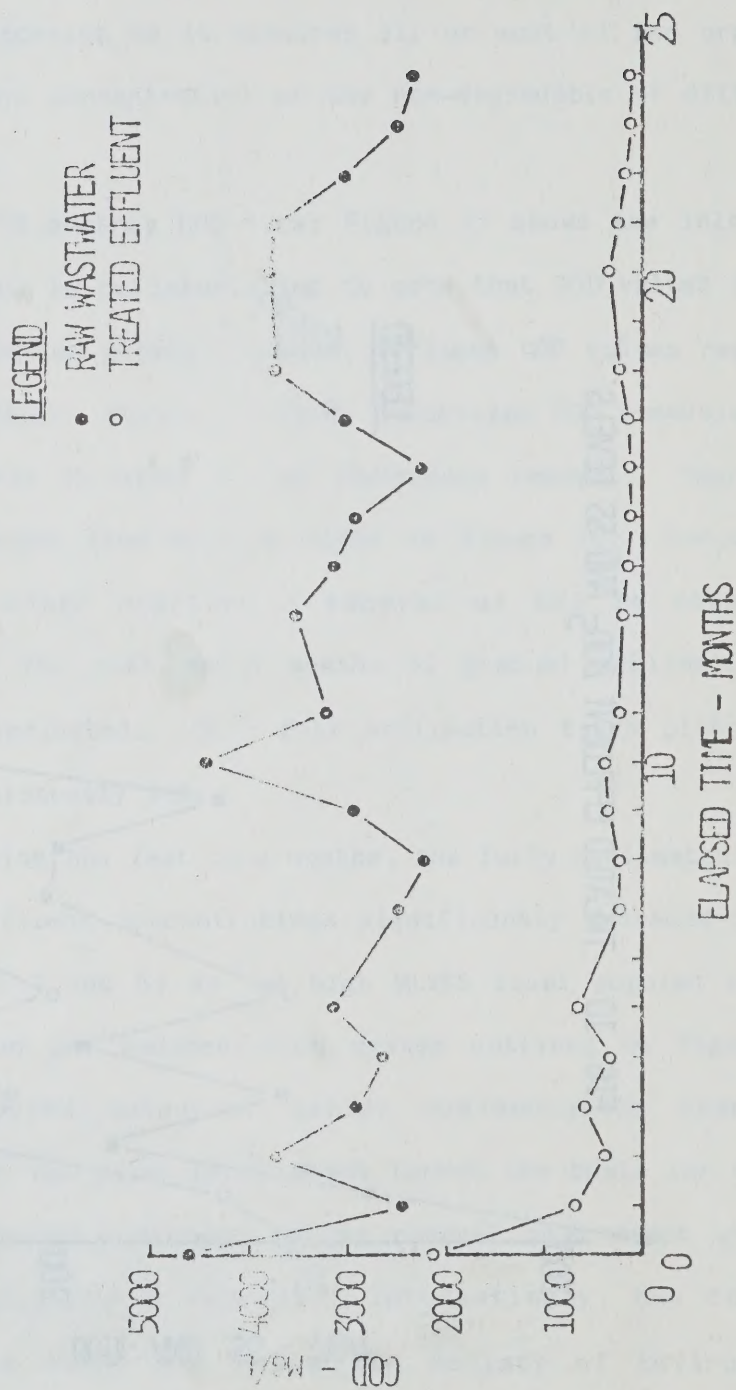


FIG. 12 CUMULATIVE COD REMOVAL

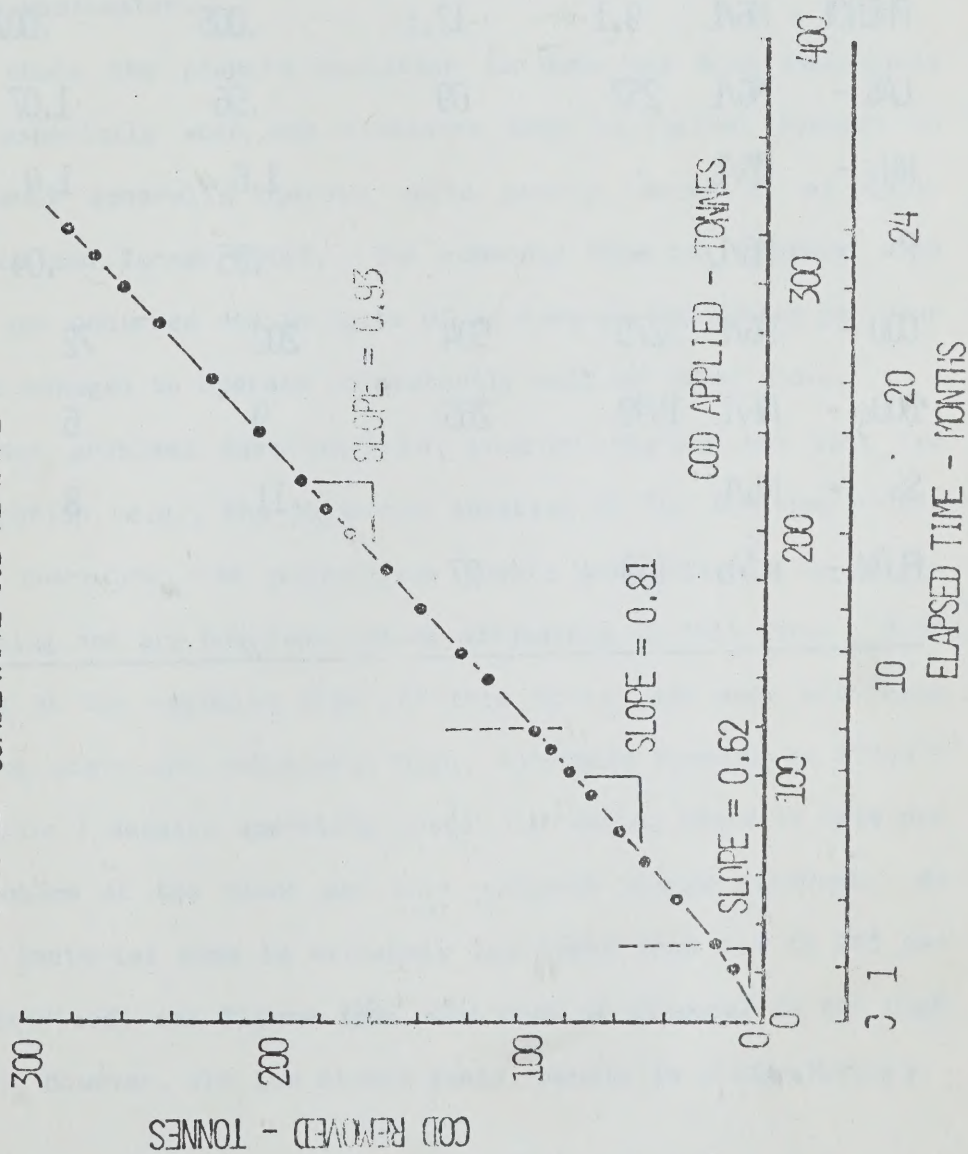


TABLE 6

AVERAGED RAW WASTEWATER AND PLANT EFFLUENT PARAMETERS DURING 1979
(SD IS STANDARD DEVIATION)

	RAW WASTEWATER		PLANT EFFLUENT	
	AVERAGE	SD	AVERAGE	SD
PHENOL - MG/L	9.1	12.1	.005	.007
LAS - MG/L	252	69	.56	1.07
NH ₃ - MG/L	-		1.6	1.4
P - MG/L	-		.05	.04
COD - MG/L	3275	504	202	72
BOD ₅ - MG/L	1599	265	9	6
SS - MG/L	-		11	8
FLOW - M ³ /D	160	27		

filtration is probably unnecessary for this plant.

Phenols and methylene blue active substances are also very low and, therefore, essentially complete detergent degradation is expected to occur. Effluent Total Kjeldahl Nitrogen (TKN) is generally less than 2 mg/l as the bacteria tend to assimilate all available nitrogen.

Finally, pH control was not required as the combination of bacterially released CO_2 plus alum addition offset the relatively high pH of the raw wastewater.

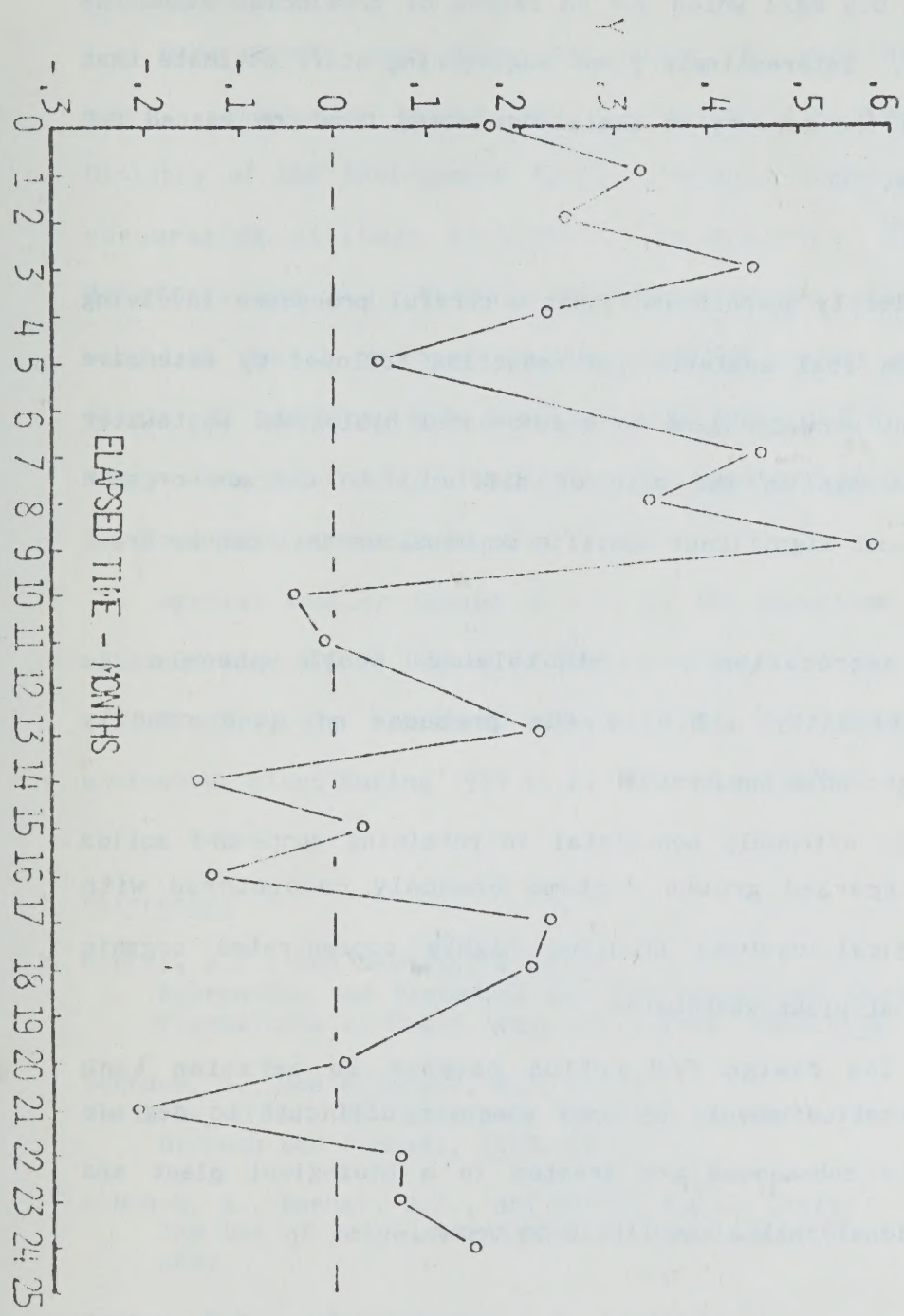
On the whole the plant's operation to date has been remarkably consistent, especially when one considers that biological systems in detergent plants generally operate quite poorly (Herin et al 1970; Holko, VanKats and Turner 1976). The commonly reported problems with foaming have not occurred and in spite of as many as ten spills per year the plant has managed to operate consistently well as noted above.

Some minor problems have occurred, however, during the last two years of operation, e.g., the polymeric sheeting of the floating covers cracked and, therefore, the polystyrene sheets were allowed to remain without sheeting and are now functioning adequately in full form. Also while looking at the negative side of this story, one must also note that operating costs are relatively high, currently running at \$71,000 per year. Table 7 details operating costs. Currently, there is only one operating problem at the plant and this concerns sludge disposal. As the yield of bacterial mass is extremely low (less than 0.1 lb VSS per lb of BOD_5 oxidized; see Figure 13). The cost of disposal is not high (see Table 7), however, the low sludge yield results in sludge Mercury

Table 7. Actual Costs Encountered (operating costs are for 1979)

Capital	471,000
Operating	
Labour	38,080
Chemicals	20,440
Waste Handling	2,680
Steam	12,000
Total operating	73,200

FIG. 13 THE YIELD OF BACTERIAL MASS PER UNIT MASS OF BOD OXIDIZED



values as high as 0.5 mg/l which are in excess of provincial standards for land disposal. Interestingly plant engineering staff estimate that as much as 60% of the mercury in the sludge comes from the wasted COD analysis solutions.

Conclusions

This paper clearly demonstrates that a careful procedure involving in plant pollution load analysis and reduction followed by extensive process development work can lead to a successful biological wastewater treatment plant design in the case of difficult to degrade organic substances. The most significant specific conclusions that can be drawn are as follows:

- (i) The degradation of ethoxylated nonyl phenols is significantly aided by the presence of more readily biodegradable substrates
- (ii) Alum is extremely beneficial in retaining suspended solids in dispersed growth systems commonly encountered with biological systems treating highly concentrated organic chemical plant wastewater
- (iii) Very low design F/M ratios coupled to aeration tank equilization should be used whenever difficult to degrade organic substances are treated in a biological plant and occasional spills are likely to occur.

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